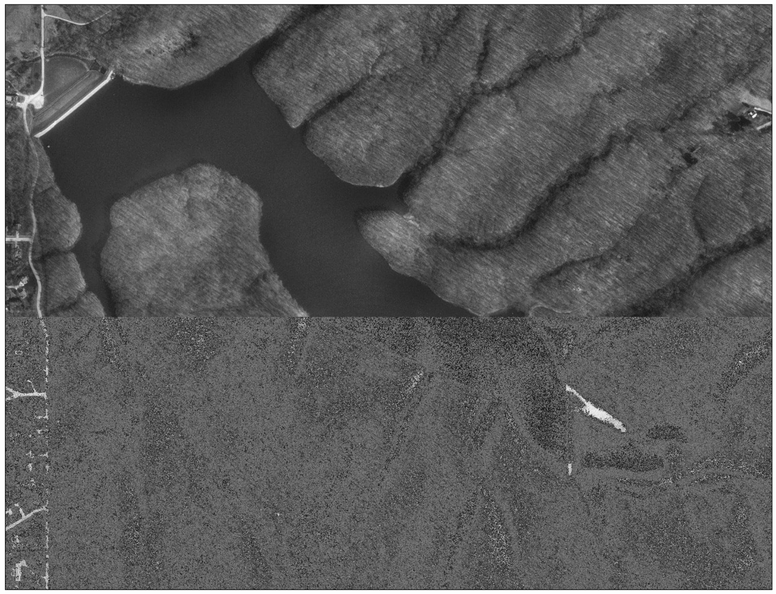

Griffy Lake
Aquatic Vegetation Management Plan

February 15, 2005

Prepared for:
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Executive Summary

Aquatic Control Inc. was contracted by Bloomington Parks and Recreation to complete aquatic vegetation sampling in order to develop a lakewide, long-term integrated aquatic vegetation management plan for Griffy Lake. Funding for development of this plan was obtained from Bloomington Parks and Recreation and the Indiana Department of Natural Resources-Division of Soil Conservation as part of the Lake and River Enhancement fund (LARE). This plan was also created as a prerequisite to eligibility for LARE program funding to control exotic or nuisance species.

Aquatic vegetation is an important component of lakes in Indiana; however, as a result of many factors this vegetation can develop to a nuisance level. Nuisance aquatic vegetation, as used in this paper, describes plant growth that negatively impacts the present uses of the lake including fishing, boating, swimming, and aesthetic values. The primary nuisance species within Griffy Lake are the exotic species Eurasian watermilfoil (*Myriophyllum spicatum)*, Brazilian elodea (*Egeria densa)*, and curlyleaf pondweed (*Potamogeton crispus)*. The 2004 plant survey found coontail (*Ceratophyllum demersum)* to be the most abundant species, but Eurasian watermilfoil and Brazilian elodea were the second and third most abundant species collected. Eurasian watermilfoil was found at 54.8% of sample sites and Brazilian elodea at 32.3%. The negative impact of these species on native aquatic vegetation, fish populations, water quality, and other factors is well documented and will be discussed in further detail. Brazilian elodea is a new introduction to Indiana, and Griffy Lake is the only public waterbody in the state with a confirmed infestation of this species. This species has caused severe problems in other states throughout the country. It is vitally important that this invader be eliminated, or at the very least, contained at this early invasion stage.

The primary goal for vegetation management in Griffy Lake should be the elimination of Brazilian elodea. Elimination of any species from a body of water is very difficult, but all steps should be taken in an effort to meet this goal. The primary step that should be taken, in an effort to meet this goal, is a whole lake application of Sonar herbicide. Ideally, prior to application a more accurate bathymetric map should be created, PlanTests conducted, and flow data from Griffy Creek should be calculated. The overall cost of this treatment along with plant surveys would be between $70,000 and $80,000. The whole lake application should be followed with multiple plant surveys and additional control strategies in order to prevent this species from recovering from the initial treatment. These additional control strategies could include lake drawdown, physical removal by divers, and/or spot treatments with contact herbicides. Follow-up plant surveys should include at least two Tier II quantitative surveys per season along with monthly visual inspections by Park personnel. This aggressive approach should expedite the re-establishment of native vegetation and reduce the chance of these invasive species being spread throughout Indiana.

A continued focus should also be placed on preserving and improving the Griffy Lake watershed. Increased urbanization of the watershed threatens the overall quality of Griffy Lake. Development of the watershed may cause an increase in siltation and a decrease in overall water quality. Increased siltation can create a more favorable environment for establishment of nuisance aquatic plant growth. Poor water quality may inhibit future efforts to establish native vegetation, increase microscopic algae blooms, reduce dissolved oxygen levels, and have negative effects on the fishery. The combination of controlling exotic vegetation along with preserving and improving Griffy Lake's watershed should help insure the future of this valuable resource.

Acknowledgements

Funding for the vegetation sampling and preparation of an aquatic vegetation management plan was provided by the Indiana Department of Natural Resources – Division of Soil Conservation and Bloomington Parks and Recreation. Aquatic Control Inc. completed the field work, data processing, and map generation. Identification and verification of questionable plant specimens was provided by Dr. Robin Scribailo of Purdue University North Central. Special thanks are due for Angie Smith and Steve Cotter of Bloomington Parks and Recreation for their help in initiating and reviewing this project. Special thanks are given to Dave Kittaka and Cecil Rich with the Indiana Department of Natural Resources for their assistance and review of this plan. Author of this report is Nathan Long of Aquatic Control. The author would like to acknowledge the valuable input from David Isaacs, Brian Isaacs, Joey Leach, and Barbie Huber of Aquatic Control for their field assistance, map generation, review, and editing of this report.

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Introduction

Aquatic Control was contracted by Bloomington Parks and Recreation to complete aquatic vegetation sampling in order to develop a lakewide, long-term integrated aquatic vegetation management plan. Funding for development of this plan was obtained from the Indiana Department of Natural Resources-Division of Soil Conservation as part of the Lake and River Enhancement fund (LARE). This plan was also created as a prerequisite to eligibility for LARE program funding to control exotic or nuisance species.

Eurasian watermilfoil, Brazilian elodea, and curlyleaf pondweed are the primary nuisance exotic species in Griffy Lake. Curlyleaf pondweed and Eurasian watermilfoil are relatively prevalent throughout Indiana and have been present in Griffy Lake for at least twenty years. However, Brazilian elodea is very rare in Indiana. It was first identified in Griffy Lake in 2001, but no action was taken. Following a 2004 plant survey, completed by IDNR district fisheries biologist Dave Kittaka, it was agreed that action must be taken to prevent the further spread of this invasive species. Brazilian elodea has been documented in only a few ponds in the southern half of the state. To our knowledge, Griffy Lake is the only public body of water containing this exotic species in Indiana. Elimination of this species should be the primary goal for the Indiana Department of Natural Resources and citizens concerned with the well being of Griffy Lake. If left unchecked, this species could spread to other lakes in Indiana where it may displace native vegetation and ruin fisheries due to its ability to form dense monoculture plant beds (Figure 1).

Figure 1. Brazilian elodea, *Egeria densa* (source: www.ecy.wa.gov/programs/wq/plants/weeds/egeria.html).

Watershed and Water Body Characteristics

Griffy Lake is a 109-acre reservoir located in Monroe county one mile north of Bloomington, Indiana. The maximum depth of Griffy Lake is 31 feet near the dam and the average depth is 10 feet. Griffy Lake was built in 1924 in order to provide additional water supply to the city of Bloomington. The dam was raised to its present height in 1943. The city of Bloomington no longer uses Griffy Lake as a water supply reservoir. Griffy Lake and a large part of the watershed is owned by the city of Bloomington and managed by Bloomington Parks and Recreation (Jones et. al. 1984).

Bloomington Parks and Recreation provided a bathymetric map of Griffy Lake for inclusion in this plan (Figure 2). It is not known when this map was created, but it is of relatively poor quality and the depths have likely changed since its creation. One recommendation for the 2005 action plan is creation of a new bathymetric map.

Figure 2. Bathymetric Map of Griffy Lake (4 foot contour intervals)

Griffy Lake's drainage basin encompasses 5,037 acres of land including the lake area. Of this total, approximately 1,200 acres are owned by the City of Bloomington (Jones et. al., 1984). The watershed is drained by Griffy Creek, which has three equally sized branches or forks. Presently, the North Fork watershed is fairly pristine, the Middle Fork is in the first stages of urbanization, and the South Fork is rapidly urbanizing (Commonwealth Biomonitoring, 2000). Public access, in the form of a boat ramp, is located in the southeast corner or upper end of the lake. This access site is managed by Bloomington Parks and Recreation. Boating is limited to electric motors only.

Dissolved oxygen and temperature were measured at 3-foot depth intervals prior to plant sampling. Water temperatures ranged from 76.0 degrees at the surface to 54.1 degrees at the bottom. Dissolved oxygen ranged from 9.49 parts per-million (ppm) at the surface to 0.07 ppm at the bottom (Figure 3). A desirable oxygen level for maintenance of healthy stress free fish was present to at least 18-feet.

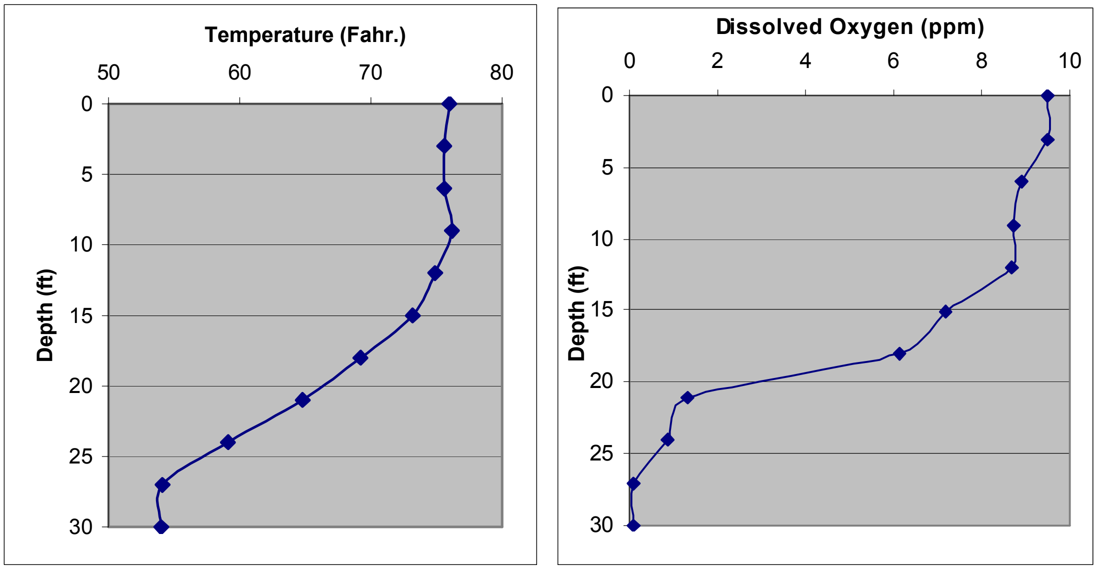

Figure 3. Dissolved oxygen temperature profile of Griffy Lake, August 31, 2004

Various studies have been completed on Griffy Lake in the last several decades. Most studies indicate Griffy Lake has good water quality despite increasing urbanization of the watershed. According to some studies the water quality has improved in the past two decades. Despite this improvement, exotic plant species dominate Griffy Lake. Typically, as watersheds are improved, water clarity will increase. This in turn will increase light penetration and allow for vegetation to grow in deeper water. Submersed vegetation obtains the majority of necessary nutrients from the sediment. Most Indiana sediments contain sufficient nutrients for plant growth. Based upon Aquatic Control's observations over the last thirty-nine years, we believe aquatic plants are not significantly limited by available phosphorus present in the water column. A study recently completed by the University of Florida compared the amount of available nutrients to plant growth. They sampled aquatic plants in 319 lakes between 1983 and 1999 and found no significant correlation between nutrients in lake water and the abundance of rooted aquatic plants (Bachman et. al. 2002). This does not imply that continued water quality monitoring and watershed improvements are not important for the future of Griffy Lake. Increased sediment and nutrient levels can have negative impacts on water quality which can lead to nuisance algae blooms, increased shallow areas, and poor dissolved oxygen levels. The above information is not meant to downplay the importance of water quality and watershed protection, but simply to clarify that improving the water quality will not effectively control nuisance exotic vegetation.

Fisheries

The latest fish survey on Griffy Lake was completed on May 17, 2004 by the Indiana Department of Natural Resources. The fish survey report was not complete at the time of this report's creation; however the fish survey data was made available by district biologist Dave Kittaka. Electrofishing, gill nets, and trap nets were used in fish collection. Dissolved oxygen and temperature were measured and results were similar to the data collected in this study. Bluegill was the most abundant species collected and comprised 58.3% of fish sampled. Bluegill ranged in length from 1.2 to 8.9 inches. Largemouth bass was second in abundance (16.3%) and ranged from 3.0 to 21.6 inches. Redear sunfish ranked third in abundance (12.8%) and ranged from 3.0 to 9.5 inches. Warmouth, longear sunfish, white sucker, black crappie, channel catfish, yellow bullhead, common carp and hybrid sunfish were also present (Table 1).

Table 1. Species Collected from Griffy Lake, May 17, 2004 (IDNR unpublished data, 2004)

Species	Number Collected	Relative Abundance	Length Range
Bluegill	357	58.33%	1.2-8.9
Largemouth Bass	100	16.34%	3.0-21.6
Redear Sunfish	78	12.75%	3.0-9.5
Warmouth	28	4.58%	1.5-8.8
Longear Sunfish	15	2.45%	2.1-6.8
White Sucker	15	2.45%	14.7-21.6
Black Crappie	7	1.14%	6.7-8.6
Channel Catfish	7	1.14%	11.6-22.1
Yellow Bullhead	3	0.49%	8.8-11.3
Common Carp	1	0.16%	28.0
Hybrid Sunfish	1	0.16%	5.5

Dense beds of submersed vegetation can have negative impacts on fish populations. Dr. Mike Maceina of Auburn University found that dense stands of Eurasian watermilfoil on Lake Guntersville proved to be detrimental to bass recruitment due to the survival of too many small bass. This led to below normal growth rates for largemouth bass and lower survival to age 1. Maceina found higher age 1 bass density in areas that contained no plants verses dense Eurasian watermilfoil stands (Maceina, 2001). It is well known by fisheries biologists that overabundant dense plant cover gives bluegill an increased ability to avoid predation and increases the survival of small young fish, which can lead to stunted growth. The Michigan Department of Natural Resources recently evaluated the effects of whole lake fluridone treatments on sport fish populations in nine different Michigan lakes for six years. They found modest statistically meaningful responses in most fish populations following treatment. From a fisheries perspective, all lake responses except one were improvements because all treatment lakes except one had a history of small-size, slow-growing, over-abundant bluegills (Schneider, 2000).

Present Water Body Uses

Griffy Lake and the immediate surroundings are owned by the city of Bloomington and managed by the Bloomington Parks and Recreation department. There are no permanent dwellings on the shoreline of Griffy Lake. Griffy Lake attracts numerous visitors from the Bloomington area. It is a very popular place for boating, fishing, picnicking, hiking, and environmental education. Griffy Lake and the surrounding watershed have been studied for many years by students and faculty from nearby Indiana University. A great deal of focus has been placed on preserving and improving the lake's watershed. Nuisance vegetation has hampered fishing and boating activities especially since the establishment of Brazilian elodea. The area surrounding the boat ramp contains some of the thickest beds of Brazilian elodea. This area has accumulated a great deal of sediment that has decreased the average depth and provided excellent substrate for the propagation of submersed macrophytes. During summer months, dense beds of Brazilian elodea make this area virtually impassable with electric motors. A more worrisome aspect of this area is the presence of the boat ramp. Brazilian elodea can spread simply by removing a fragment and introducing it to a new waterbody. It is likely that this species has been removed on boats and boat trailers and transported to other waterbodies in the state.

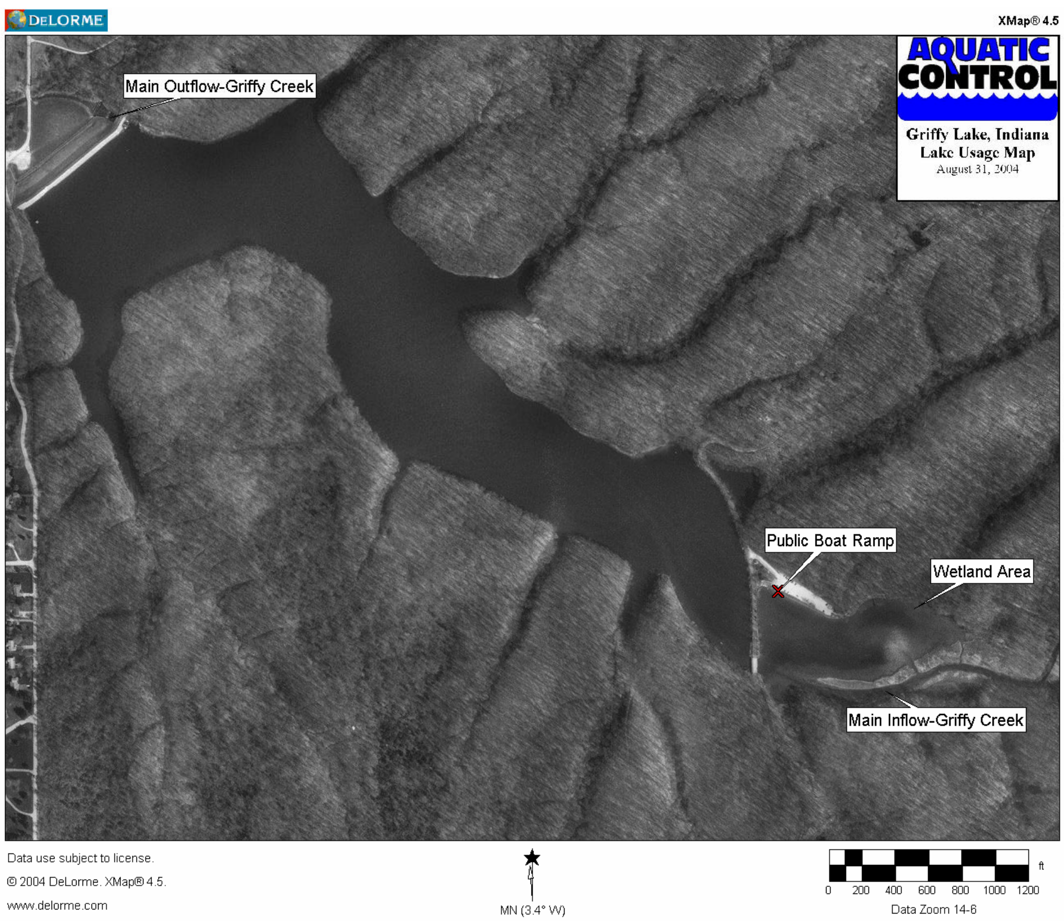

Figure 4. Lake Usage Map (not to scale see appendix)

Aquatic Plant Community

In order to create an effective vegetation management plan the plant community must be sampled. Griffy Lake's aquatic vegetation has been sampled prior to 2004. A visual survey was conducted in 1984 and found curlyleaf pondweed to be abundant in the upper 1/3 of the reservoir growing to a depth of 15 feet (Jones et. al., 1984). Griffy Lake was chosen for a milfoil weevil study in 2000. Brazilian elodea was first documented during this sampling. Eurasian watermilfoil was the focus of the study and was mapped over a three-year period. During the 3-year study period milfoil declined progressively in the eastern bay of Griffy Lake while Brazilian elodea increased proportionately (Scribailo, 2003).

District fisheries biologist Dave Kittaka conducted sampling on Griffy Lake, July 15, 2004 prior to a fish survey. The sampling method used basically the same protocol as the Tier II sampling which will be discussed later in the report. Forty sites were sampled. Coontail was found at the highest percentage of sites (85%), followed by Eurasian watermilfoil (55%) and Brazilian elodea (35%). Sago pondweed, curlyleaf pondweed, horned pondweed, brittle naiad, chara, and creeping water primrose were also collected.

Tier I and Tier II sampling was completed by Aquatic Control on August 31, 2004. In order to accurately document changes in plant community characteristics that occur through the course of the spring through late summer seasons two Tier II surveys should be completed in a season, but due to time limitations, a single survey was completed in 2004.

Tier I Survey
The Tier I survey was developed to serve as a qualitative surveying mechanism for aquatic plants. The Tier I survey is based upon the procedure manual developed by Shuler & Hoffmann, 2002. This survey will serve to meet the following objectives:

1. to provide a distribution map of the aquatic plant species within a waterbody
2. to document gross changes in the extent of a particular plant bed or the relative abundance of a species within a waterbody (IDNR, 2004)

The Tier I survey revealed eight distinct plant beds within Griffy Lake totaling 66.13 acres. (Table 2 & Figure 5). For purposes of the Tier I survey plant beds are defined as contiguous, consistent (similar composition) aquatic plant communities. Fourteen plant species were identified within the eight plant beds. Species were identified in each plant bed and given an abundance rating based on a scale of 1-4 with 1 representing less than 2% abundance and 4 representing greater than 60% abundance.

Table 2. Tier I Survey Results

Plant Bed I.D.	#1	#2	#3	#4	#5	#6	#7	#8
Plant Bed Size (acres)	4.64	6.54	10.34	9.34	1.98	2.80	3.25	15.39
	Rating*	Rating*	Rating*	Rating*	Rating*	Rating*	Rating*	Rating*
Eurasian watermilfoil**	2	2	3	3	3	3	3	3
Brazilian elodea*	1	4	2	1	2	2	3	1
Curlyleaf pondweed*	-	1	1	1	1	1	-	1
Coontail	2	2	2	2	2	3	2	3
Brittle naiad	4	3	3	2	3	-	2	1
Slender naiad	-	-	1	-	-	-	-	-
American pondweed	1	1	1	2	2	2	1	1
Sago pondweed	-	1	2	2	1	-	-	1
Small pondweed	-	-	1	-	1	-	-	-
Creeping water primrose	2	1	1	1	-	-	1	1
Chara		1	-	1	-	-	-	-
American water willow	-	-	1	1	1	2	1	1
Duckweed	1	1	-	-	-	-	-	-
Common cattail	2	-	-	-	-	-	-	-

*Rating refers to density which is scored from 1-4, 1 being least dense and 5 being most dense
**exotic species

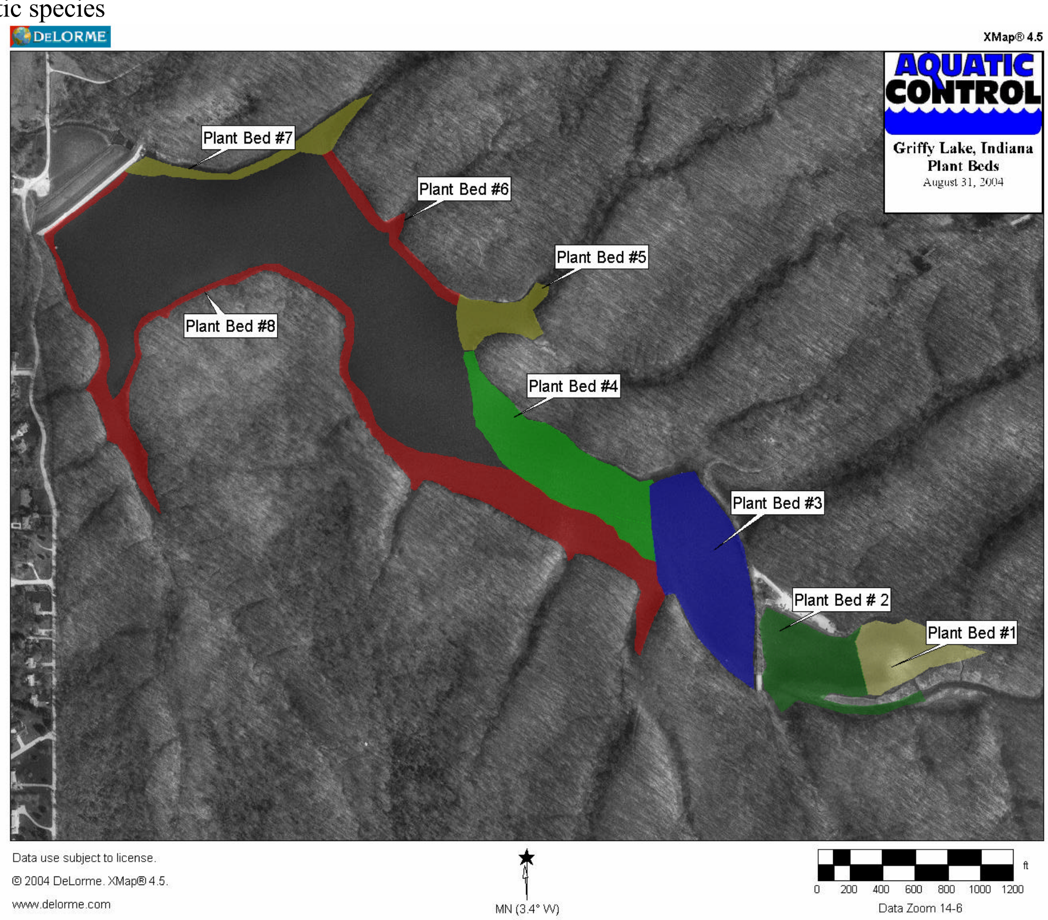

Figure 5. Tier I Plant Beds, Griffy Lake, August 31, 2004 (not to scale see appendix)

Plant bed 1 was determined to be 4.64 acres and the substrate was predominantly silt/clay and high in organics. Eight species were observed within the plant bed. Brittle naiad was the dominant plant species (>60% abundance rating), followed by creeping water primrose, Eurasian watermilfoil , coontail, and common cattail (2-20%). Brazilian elodea, duckweed, and American pondweed were also present in plant bed 1 (<2%). Between 21% and 60% of bed one contained plants that reached the surface and created a canopy.

Plant bed 2 was determined to be 6.54 acres and the substrate was silt/clay and high in organics. A total of ten species were observed within the plant bed. Brazilian elodea was the dominant plant species (>60% abundance rating). Brittle naiad was second in abundance (21-60%) followed by Eurasian watermilfoil, and coontail (2-20%). Curlyleaf pondweed, duckweed, sago pondweed, creeping water primrose, chara and American pondweed were also present in plant bed two at less than 2% abundance. Between 2-20% of plant bed 2 contained plants that reached the surface and created a canopy. Plant bed 2 should be considered an area of concern due to the dominance of Brazilian elodea and the nearby boat ramp.

Plant bed 3 was the second largest plant bed at 10.34 acres. The substrate of plant bed 3 was silt/clay and high in organics. A total of eleven species were observed within the plant bed. Eurasian watermilfoil and brittle naiad were the dominant plant species (21-60% abundance rating). Brazilian elodea, coontail, and sago pondweed ranked second in abundance (2-20%). Curlyleaf pondweed, American water willow, American pondweed, creeping water primrose, small pondweed and slender naiad were also present in plant bed 3 at less than 2% abundance. Between 2-20% of plant bed 3 contained plants that reached the surface and created a canopy.

Plant bed 4 was determined to be 9.34 acres and the substrate was gravel/rock. A total of ten species were observed within the plant bed. Eurasian watermilfoil was the dominant plant species (21-60% abundance rating). Brittle naiad, coontail, American pondweed, and sago pondweed ranked second in abundance (2-20%). Curlyleaf pondweed, Brazilian elodea, chara, creeping water primrose, and American water willow were also present in plant bed 4 at less than 2% abundance. Between 2-20% of plant bed 4 contained plants that reached the surface and created a canopy.

Plant bed 5 was the smallest plant bed at 1.98 acres. The substrate of plant bed 5 was silt/clay and high in nutrients. A total of nine species were observed within the plant bed. Eurasian watermilfoil and brittle naiad were the dominant plant species (21-60% abundance rating). Brazilian elodea, coontail, and American pondweed ranked second in abundance (2-20%). Curlyleaf pondweed, sago pondweed small pondweed, and American water willow were also present in plant bed 5 at less than 2% abundance. Between 2-20% of plant bed 5 contained plants that reached the surface and created a canopy.

Plant bed 6 was determined to be 2.80 acres. The substrate of plant bed 6 was gravel/rock. A total of six species were observed within the plant bed. Eurasian watermilfoil and coontail were the dominant plant species (21-60% abundance rating). Brazilian elodea, American water willow, and American pondweed ranked second in abundance (2-20%). Curlyleaf pondweed was also present in plant bed 6 at less than 2% abundance. Between 2-20% of plant bed 6 contained plants that reached the surface and created a canopy.

Plant bed 7 was determined to be 3.25 acres. The substrate of plant bed 7 was gravel/rock. A total of seven species were observed within the plant bed. Eurasian watermilfoil and Brazilian elodea were the dominant plant species (21-60% abundance rating). Brittle naiad and coontail ranked second in abundance (2-20%). American pondweed, creeping water primrose, and American water willow were also present in plant bed 7 at less than 2% abundance. Between 2-20% of plant bed 7 contained plants that reached the surface and created a canopy.

Plant bed 8 was the largest plant bed at 15.39 acres. The substrate of plant bed 8 was gravel/rock. A total of nine species were observed within the plant bed. Eurasian watermilfoil and coontail were the dominant plant species (21-60% abundance rating). American pondweed, creeping water primrose, American water willow, sago pondweed, brittle naiad, and Brazilian elodea were also present in plant bed 8 at less than 2% abundance. Less than 2% of plant bed 8 contained plants that reached the surface and created a canopy.

Tier II Survey

Creation of the aquatic vegetation management plan also requires sampling to quantify the occurrence, distribution, and abundance of aquatic vegetation. This type of survey will be referred to as the Tier II survey. This protocol is currently being used by the IDNR Division of Fish and Wildlife to provide a quantitative sampling mechanism for aquatic plant surveying. This protocol supplements the Tier I Reconnaissance Protocol for plant bed mapping. Together the protocols should serve to meet the following objectives:

1. to document the distribution and abundance of submersed and floating-leaved aquatic vegetation
2. to compare present distribution and abundance with past distribution and abundance within select areas (IDNR, 2004).

All of the data that was collected through the use of this protocol was recorded on standardized data sheets (Appendix C summarizes the data sheets). The data collected was compared to data collected by district fisheries biologist Jed Pearson, which is presented in his 2004 paper “A Proposed Sampling Method to Assess Occurrence, Abundance, and Distribution of Submersed Aquatic Plants in Indiana Lakes”. In this paper, Pearson used 21 northern Indiana lakes to calculate various aquatic plant abundance and diversity metrics (Pearson, 2004). We used the same sampling procedure outlined in Pearson’s paper to calculate these same metrics for Griffy Lake. Pearson’s paper focused on natural lakes in Northern Indiana, so the data we collected is not easily compared. However, it is the only data that has been made available using this relatively new technique. Most importantly, data collected will be valuable for future comparison, which will document changes in Griffy Lake's plant community following proposed management activities.

A total of 62 sample sites were randomly selected within the littoral zone of Griffy Lake. Once a site was reached the boat was slowed to a stop and the coordinates were recorded on a hand-held GPS unit and later downloaded into a mapping program. A depth measurement was taken by dropping a two-headed standard sampling rake that was attached to a rope marked off in 1-foot increments (Figure 6). An additional ten feet of rope was released and the boat was reversed at minimum operating speed for a distance of ten feet. Once the rake was retrieved the overall plant abundance on the rake was scored from 1-5 and then individual species were placed back on the rake and scored separately (the rake is marked off in 5 equal section on the tines).

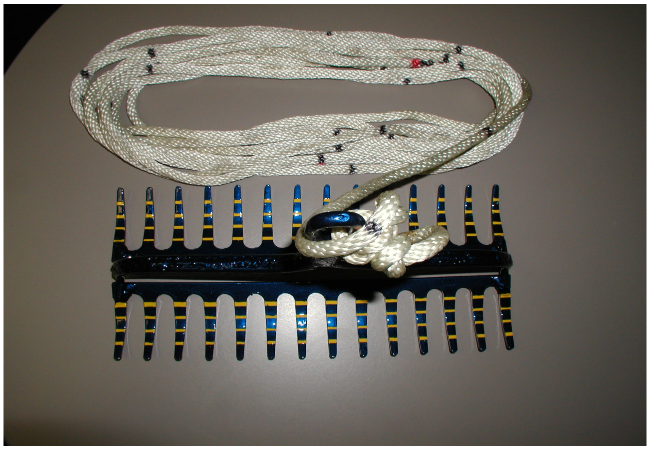

Figure 6. Sampling Rake

Tier II sampling took place on August 31, 2004 immediately following the Tier I sampling. A total of sixty-two sites were randomly selected throughout the littoral zone (Figure 7). A Secchi disk reading was taken prior to sampling and was found to be 10-feet. Plants were present to a maximum depth of 20 feet. The mean depth from which samples were taken was 8.02 feet. The mean rake density score for Griffy Lake was 3.92. Species richness (average number of species per site) was 2.10. Site species diversity index was 0.75. Griffy Lake appears to have a good diversity and abundance of aquatic vegetation compared to other lakes in the state. However, a large part of this diversity and abundance is made up of exotic species. Figure 8 illustrates the overall distribution and abundance of aquatic vegetation.

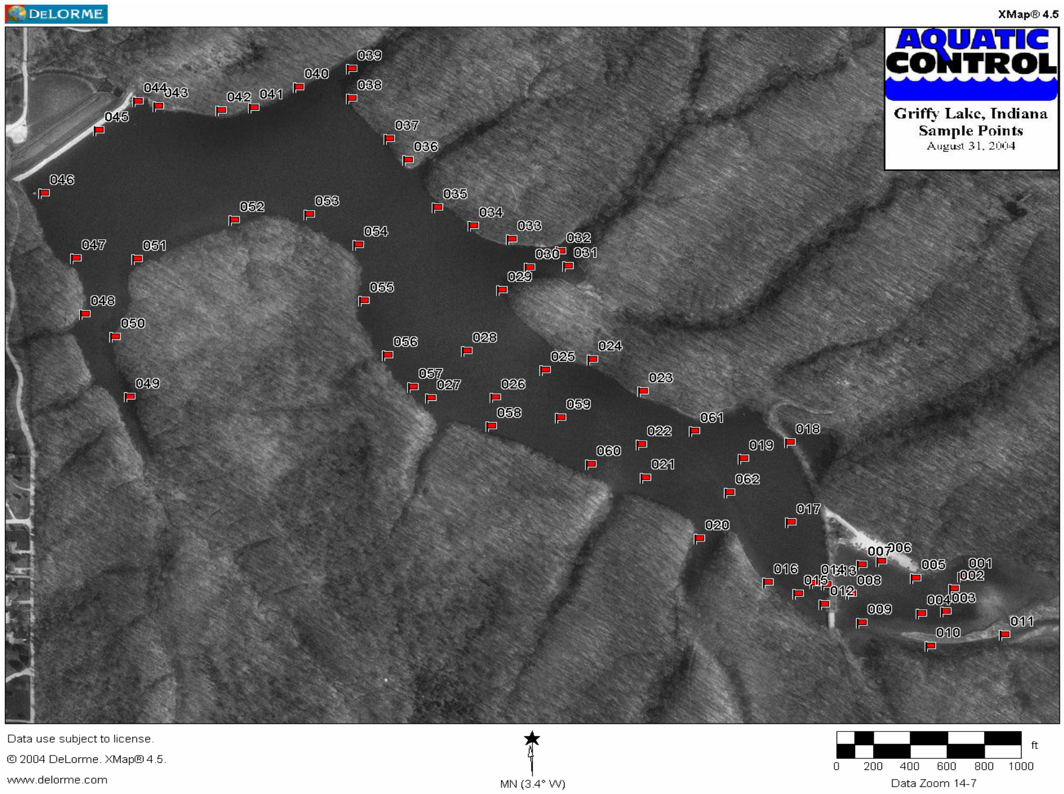

Figure 7. Tier II Sample Points (not to scale see appendix)

Table 3. Griffy lake vegetation abundance, density, and diversity metrics compared to average**

	Griffy Lake*	Average**
Aquatic Vegetation Frequency of Occurrence	94%	-
# of species collected	10	8
# of native species collected	7	7
Mean Rake Density	3.92	3.30
Rake Diversity (SDI)	0.68	0.62
Species Richness (Avg # spec./site)	2.10	1.61
Site Species Diversity	0.75	0.66

*standard deviation not included
**average calculated from Pearson Data comparing 21 Northern Indiana natural lakes.

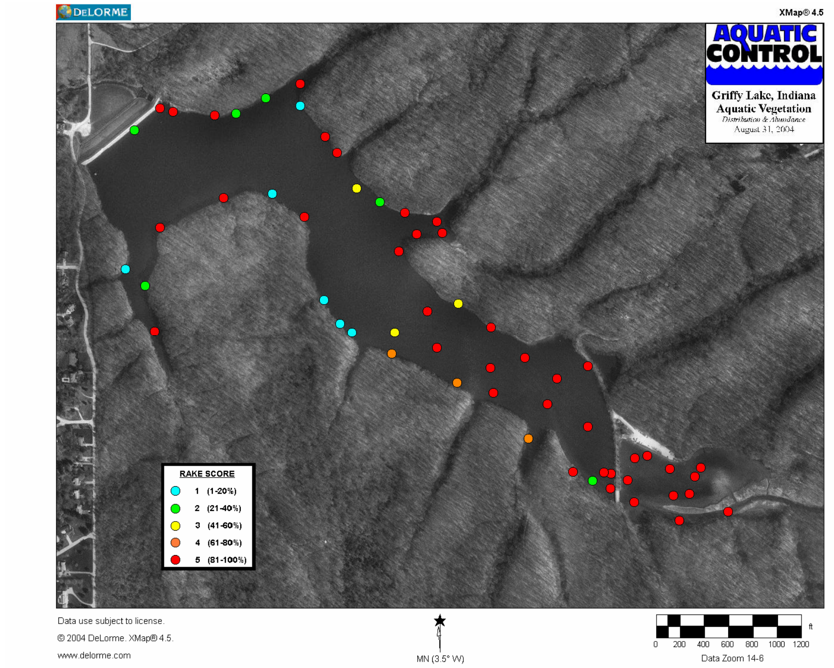

Figure 8. Aquatic vegetation distribution and abundance (not to scale see appendix)

Tier II sampling also allows one to map location, frequency of occurrence, and density of individual species. Non-native species collected were Brazilian elodea, curlyleaf pondweed, and Eurasian watermilfoil. Table 4 breaks down the individual species by frequency of occurrence, relative density, and dominance. Coontail was present in the highest percentage of sample sites (80.6%) (Figure 9), followed by Eurasian watermilfoil (54.8%) (Figure 10), Brazilian elodea (32.3%) (Figure 11), brittle naiad (*Najas minor)* (21%) (Figure 12), sago pondweed *(Potamogeton pectinatus)* (8.1%) (Figure 13), curlyleaf pondweed (3.2%) (Figure 14), chara (*Chara sp.)* (3.2%), and slender naiad (*Najas flexilis*) (3.2%) (Figure 15). American pondweed and small pondweed were collected at a single site.

Table 4. Species collected during Tier II sampling.

Common Name	Scientific Name	Frequency of Occurrence	Relative Density*	Dominance Index**
Coontail	*Ceratophyllum demersum*	80.6	2.79	55.8
Eurasian watermilfoil	*Myriophyllum spicatum*	54.8	0.94	18.7
Brazilian elodea	*Egeria densa*	32.3	0.77	15.5
Brittle naiad	*Najas minor*	21.0	0.60	11.9
Sago pondweed	*Potamogeton pectinatus*	8.1	0.10	1.9
Curlyleaf pondweed	*Potamogeton crispus*	3.2	0.03	0.6
Chara	*Chara sp.*	3.2	0.16	3.2
Slender naiad	*Najas flexilus*	3.2	0.03	0.6
American pondweed	*Potamogeton nodosus*	1.6	0.03	0.6
Small pondweed	*Potamogeton pusillus*	1.6	0.02	0.3

*relative density=mean rake scores at all sites
**percent of maximum abundance

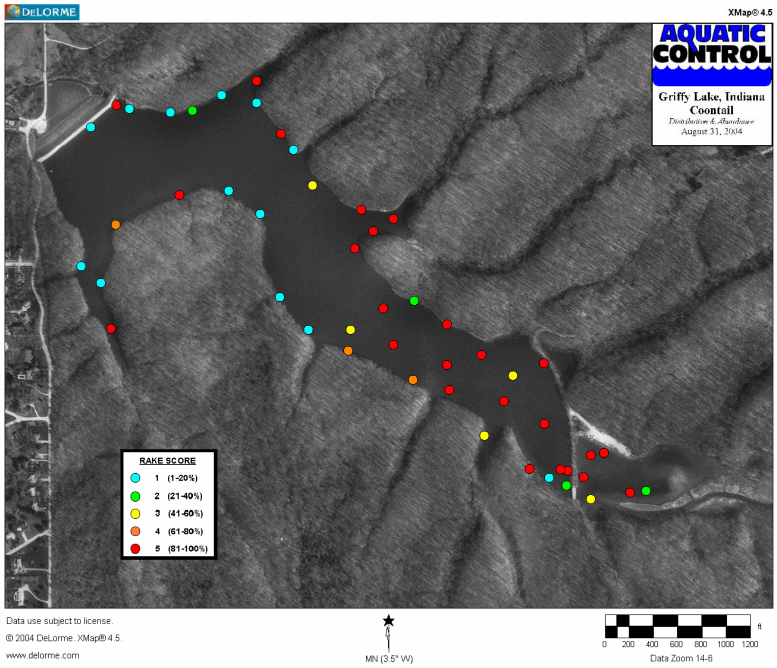

Figure 9. Coontail distribution and abundance (not to scale see appendix)

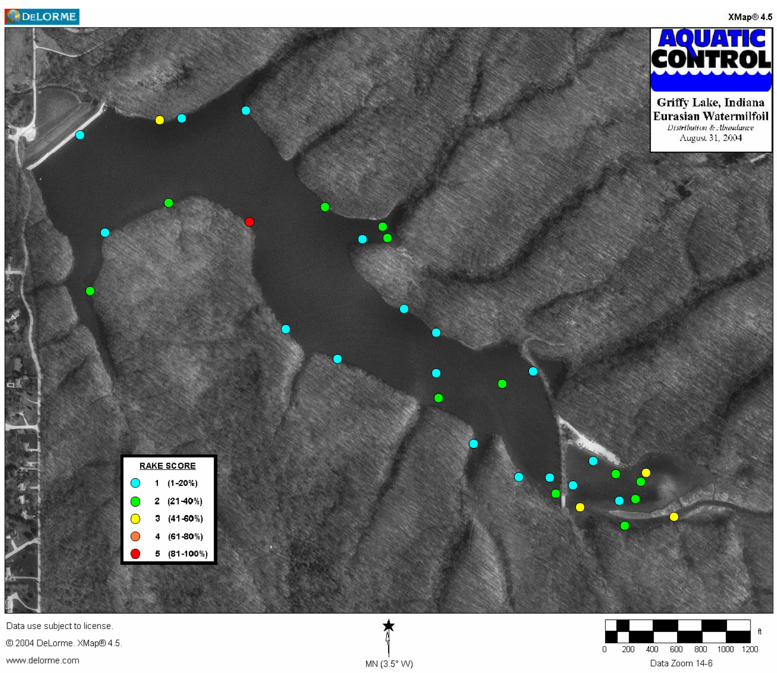

Figure 10. Eurasian watermilfoil distribution and abundance (not to scale see appendix)

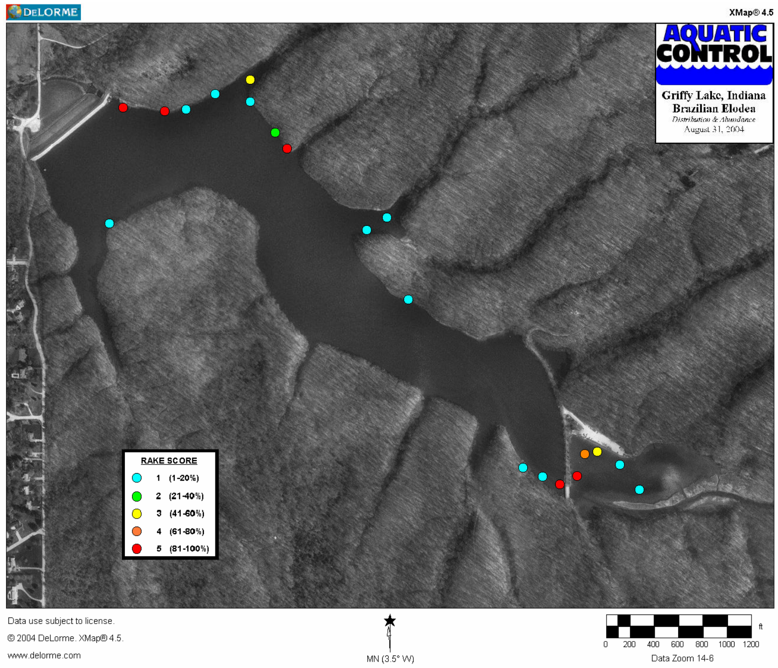

Figure 11. Brazilian elodea distribution and abundance (not to scale see appendix)

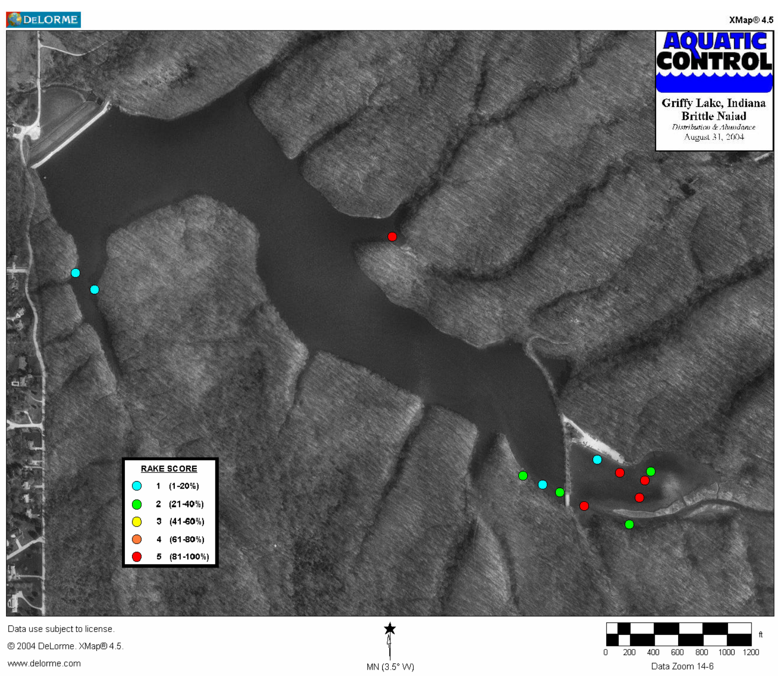

Figure 12. Brittle naiad distribution and abundance (not to scale see appendix)

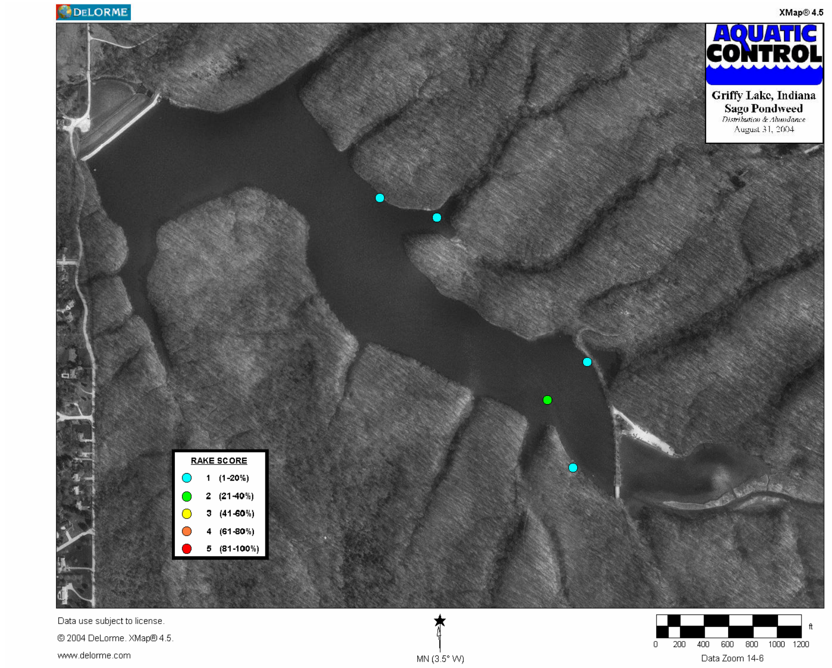

Figure 13. Sago pondweed distribution and abundance (not to scale see appendix)

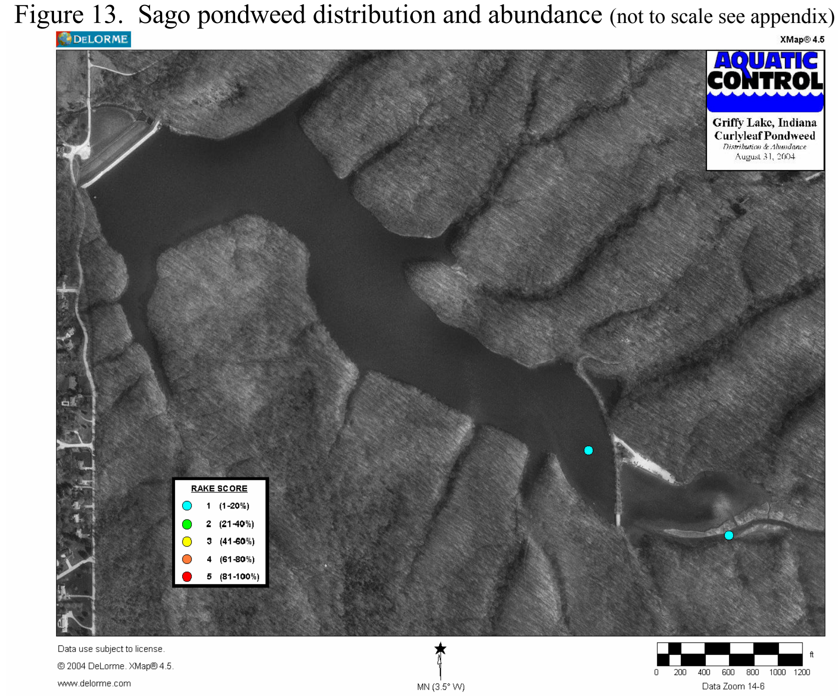

Figure 14. Curlyleaf pondweed distribution and abundance (not to scale see appendix)

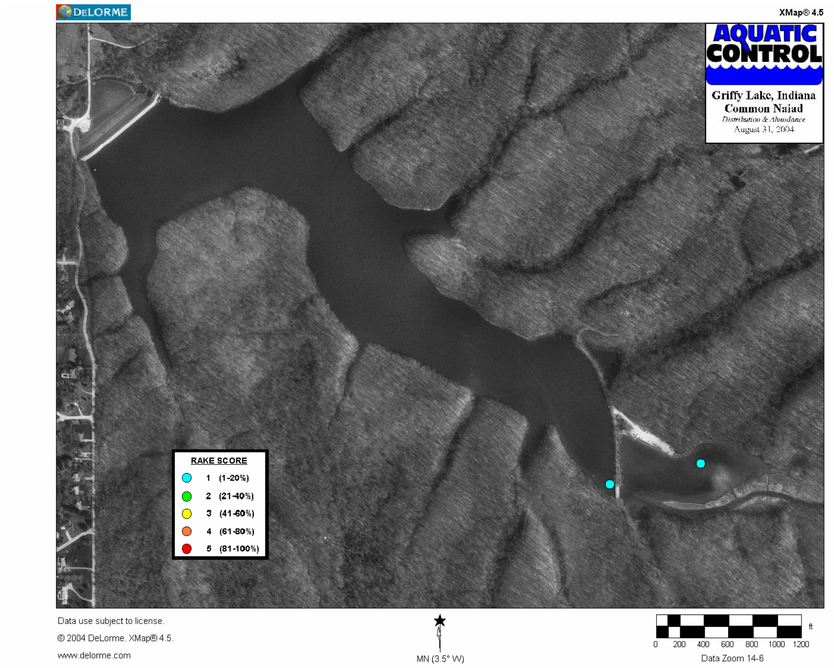

Figure 15. Slender naiad distribution and abundance (not to scale see appendix)

Plant Management History

Limited plant management activity has taken place on Griffy Lake despite the presence of three nuisance exotic species (Table 5). To our knowledge there have been only two attempts to manage exotic vegetation in Griffy Lake. Beginning in 2000, Scribalio conducted a three-year milfoil weevil stocking program on Griffy Lake. There was no conclusive evidence of any control from the milfoil weevils. In early September 2004, the Indiana Department of Natural Resouces-Division of Fish and Wildlife treated an area of Brazilian elodea with diquat herbicide. The treatment took place in the vicinity of the public boat ramp and comprised less than 1 acre of vegetation. The Department of Natural Resources initiated this treatment due to concern over the transport of Brazilian elodea to other public and private waterbodies. The treatment was considered to be initially successful, but some Brazilian elodea returned prior to the end of the season .

Table 5. Griffy Lake Treatment History

Year	Treatment Activity
2000	Milfoil weevil
2001	Milfoil weevil
2002	Milfoil weevil
2003	No treatment
2004	Less than 1 acre of Brazilian elodea treated near boat ramp with diquat herbicide

Aquatic Plant Management Alternatives

Three exotic species were documented in Griffy Lake during Tier I and Tier II sampling: Brazilian elodea, Eurasian watermilfoil, and curlyleaf pondweed. At the time of sampling, Brazilian elodea and Eurasian watermilfoil were present at potentially nuisance levels.

Curlyleaf pondweed was collected at only two sites; however this species typically reaches maximum biomass in spring. According to past sampling, curlyleaf pondweed has been present at nuisance levels (Jones et. al., 1984). Curlyleaf pondweed will likely make up a much larger percentage of the potential spring sampling. This species can form dense monocultures during April and May. Potential adverse effects of dense stands of this species include: providing too much cover for prey species of fish, resulting in stunted fish growth; microscopic algae blooms caused by large-scale early summer die offs and interference with boating and fishing activities. Action should be taken in order to reduce the impact of curlyleaf pondweed.

Eurasian watermilfoil is abundant in Griffy Lake and should be appropriately managed. It is believed that Eurasian watermilfoil was first introduced from Eurasia or North Africa to an area near Maryland around 1942, possibly through the aquarium trade. Some reports suggest that this species may have been introduced into North America as early as the late 1800's through shipping ballast (Ditomaso & Healy, 2003). This species has now spread throughout the majority of North America and is the primary nuisance submersed aquatic species in Indiana. Once established, growth and physiological characteristics of Eurasian watermilfoil enable it to form a surface canopy and develop into immense stands of weedy vegetation, out competing most submersed species and displacing the native plant community (Madsen et al., 1988).

A number of different techniques have been successfully used to control Eurasian watermilfoil. These techniques vary in terms of their efficacy, rapidity, and selectivity, as well as the thoroughness and longevity of control they are capable of achieving. Each technique has advantages and disadvantages, depending on the circumstances. Selectivity is a particularly important characteristic of control techniques. Nearly all aquatic plant control techniques are at least somewhat selective, in that they affect some plant species more than others. Even techniques such as harvesting that have little selectivity within the areas to which they are applied can be used selectively, by choosing only certain areas in which to apply them. Selectivity can also occur after the fact, as when a technique controls all plants equally but some grow back more rapidly. One facet of selecting an appropriate aquatic plant control technique is matching the selectivity of the control technique with the goals of aquatic plant management. When controlling Eurasian watermilfoil for example, it is typically desirable to use techniques that control Eurasian watermilfoil with minimal impact on most native species (Smith, 2002).

The exotic species of highest concern in Griffy Lake is Brazilian elodea. This species is native to the central Minas Geraes region of Brazil and the coastal areas of Argentina and

Uraguay. The plant has spread to New Zealand, Australia, Hawaii, Denmark, Germany, France, Japan, and Chile. The earliest report of Brazilian elodea in the United States was from Millneck, Long Island where the plant was collected in 1893 (Gibbons et al. 1999). This species is now present throughout the southeastern part of the United States, the northeastern seaboard excluding Maine, and the entire west coast. Severe infestations are found in the California delta and several large lakes in Washington State and Oregon. California dedicated 2 million dollars in 2000 to manage this species in the Sacramento-delta area.

Brazilian elodea was originally discovered in Griffy Lake in 2001, but it was mis-identified as the exotic species Hydrilla (*Hydrilla verticillata*). This identification raised suspicion since Hydrilla had never been found in Indiana. A sample was sent to the University of Florida where it was identified as Brazilian elodea (these species are very similar in appearance and easily confused). Brazilian elodea has been documented in only a few small ponds in southern Indiana. These populations most likely occurred from aquarium plants which were unintentionally or intentionally introduced. It is unclear how Brazilian elodea was introduced into Griffy Lake, but most likely involved aquarium raised plants. This species is very popular with the aquarium industry due to its robust size and its ability to be easily propagated from stem fragments. These attributes also make it a nuisance plant once it reaches a waterbody. Brazilian elodea forms dense monospecific stands that compete with native vegetation, trap sediment, interfere with fishing and boating activities, and can negatively impact fish populations.

In order to develop a scientifically sound and effective action plan for control of these nuisance exotic species, all aquatic management alternatives need to be considered. The alternatives that will be discussed include: no action; environmental manipulation; chemical, mechanical, or biological control methods; and any combination of these methods. At the end of this section, Table 6 summarizes these aquatic plant management alternatives.

No Action

What if no aquatic plant management activity took place on Griffy Lake? This is an easy question to answer since very little plant management activity has taken place and exotic species appear to dominate the aquatic plant fauna. Most areas between one and ten feet were dominated by either Eurasian watermilfoil or Brazilian elodea. If no management activity is initiated, the exotic species will likely remain near the same abundance or continue to spread throughout the lake.

The main drawback to not initiating any management strategies would be the potential spread of Brazilian elodea to other waterbodies. Currently, this nuisance species is not present in any other public waters in the state of Indiana. As previously mentioned, this species spreads by stem fragments. A small piece of Brazilian elodea can generate large numbers of plants which could potentially infest lakes, rivers, and reservoirs throughout the state. It is important to eliminate, or at the very least, isolate Brazilian elodea in Griffy Lake.

Environmental manipulation
Environmental manipulation for Griffy Lake would include water level draw-down. Successful use of water draw-down for controlling Eurasian watermilfoil and Brazilian elodea typically requires drawing down water levels sufficiently to expose the entire populations. This technique can be effective if the drawdown exposes the entire population to freezing and thawing, however drawdown can result in the expansion of these species into deeper water. Drawdown can also have negative affects on native plant species and over-wintering amphibians.

The ability to easily raise and lower water levels is not available at Griffy Lake. A pumping or siphoning system would have to be put in place near the dam in order to lower the water level or the sluice gate will need repair. A tremendous amount of water would have to be removed in order to expose all areas that contain aquatic plants (species are growing in up to 20 feet of water). However, drawdown could help control Brazilian elodea near the boat ramp area due to the shallow water near the upper end of the lake. This technique should be considered in combination with other control techniques. Steps should be taken to repair the sluice gate in order to make drawdown a more feasible control technique.

Mechanical
Mechanical control includes cutting, dredging, or tilling the bottom sediments to eliminate aquatic plant growth. The main advantage to mechanical control is the immediate removal of the plant growth from control areas and the removal of organic matter and nutrients.

One of the most common mechanical control techniques used on larger lakes in Indiana is mechanical harvesting. Mechanical harvesting uses machines which cut plant stems and, in most cases, pick up the cut fragments for disposal. This type of mechanical control has little selectivity. Where a mix of exotic and native species exists, harvesting favors the plant species that grows back most rapidly following harvesting. In most cases, Eurasian watermilfoil recovers from harvesting much more rapidly than native plants. Thus, repeated harvesting hastens the replacement of native species by Eurasian watermilfoil and often leads to dense monocultures of Eurasian watermilfoil in frequently harvested areas. Harvesting also stirs up bottom sediments thus reducing water clarity, kills fish and many invertebrates, and hastens the spread of Eurasian watermilfoil and Brazilian elodea via fragmentation. For these reasons, harvesting is not recommended as a primary control method for exotic species in Griffy Lake. However, if a large-scale treatment takes place and only a few plants remain harvesting may be completed by divers. Divers would need to remove the entire plant including the root structure. This would only be feasible if there is limited exotic vegetation requiring control.

Biological
Biological controls reduce aquatic vegetation using other organisms that consume aquatic plants or cause them to become diseased (Smith, 2002). The main biological controls for Eurasian watermilfoil used in Indiana are the white amur (grass carp) and the milfoil

weevil. To our knowledge, no biological control is available for Brazilian elodea or curlyleaf pondweed.

The white amur or grass carp *Ctenopharyngodon idella* is a herbivorous fish imported from Asia. Triploid grass carp, the sterile genetic derivative of the diploid grass carp, are legal for use in Indiana. Grass carp tend to produce all or nothing aquatic plant control. It is very difficult to achieve a stocking rate sufficient to selectively control nuisance species without eliminating all submersed vegetation. Another drawback to the stocking of grass carp is that they are difficult to remove from a lake once they have been stocked. They are not particularly appropriate for Eurasian watermilfoil or culyleaf pondweed control because these species are low on their feeding preference list; thus, they eat most native plants before consuming these exotic species. However, Brazilian elodea is relatively high on the feeding preference list along with several other native species present in Griffy Lake. Stocking of grass carp may reduce the abundance of Brazilian elodea, but this may cause an increase in Eurasian watermilfoil and curlyleaf pondweed. Grass carp are not recommended for exotic species control in Griffy Lake.

The milfoil weevil, *Euhrychiopsis lecontei,* is a native North American insect that consumes Eurasian and Northern watermilfoil. The weevil was discovered following a natural decline of Eurasian watermilfoil in Brownignton Pond, Vermont (Creed and Sheldon, 1993), and has apparently caused declines in several other water bodies. Weevil larvae burrow in the stem of Eurasian watermilfoil and consume the vascular tissue thus interrupting the flow of sugars and other materials between the upper an lower parts of the plant. Holes where the larvae burrow into and out of the stem allow disease organisms a foothold in the plants and allow gases to escape from the stem, causing the plants to lose buoyancy and sink (Creed et al. 1992).

Concerns about the use of the weevil as a biological control agent relate to whether introductions of the milfoil weevil will reliably produce reductions in Eurasian watermilfoil and whether the resulting reductions will be sufficient to satisfy users of the lake (Smith, 2002). Following our research, no conclusive data concerning the role of weevils in reducing Eurasian watermilfoil populations has been made available. In 2003, Scribailo & Alix conducted a weevil release study on three Indiana lakes and had no conclusive evidence supporting the use of weevils in reducing milfoil populations. One of the lakes included in the study was Griffy Lake. Weevils may reduce milfoil populations in some lakes, but predicting which lakes and how much, if any, control will be achieved has not been documented. Weevils will not control curlyleaf pondweed or Brazilian elodea.

Chemical Control

Chemical control uses chemical herbicides to reduce or eliminate aquatic plant growth. The main advantage of using herbicides is their relatively quick results and proven effectiveness. However, applying chemicals specifically designed for killing organisms to a public body of water can create controversy. Modern aquatic herbicides have been extensively tested to ensure that they can safely be used in the aquatic environment. Among other things, these tests ensure that they are low in toxicity to human and aquatic animals and that they are not overly persistent or bioaccumulated in fish or other organisms (Smith, 2002). An aquatic herbicide cannot be legally used if it has not been registered with EPA's Office of Pesticide Programs.

There are two different types of aquatic herbicides; systemic and contact. Systemic herbicides are translocated throughout the plant and thereby kill the entire plant. Fluridone (trade name Sonar & Avast!), 2,4-D (trade name Navigate, Aqua-Kleen, & DMA4 IVM), and trichlopyr (trade name Renovate) are systemic herbicides that can effectively control Eurasian watermilfoil. Fluridone is the only registered systemic herbicide which can also effectively control curlyleaf pondweed and Brazilian elodea.

Based upon the author's experience and personal communication with a vast array of North American aquatic plant managers, whole-lake fluridone applications are by far the most effective means of controlling Eurasian watermilfoil, Brazilian elodea and curlyleaf pondweed when found in combination. In most cases, an advantage to using fluridone over most contact herbicides is its selectivity. Most strains of Eurasian watermilfoil have a lower tolerance to fluridone than the majority of native species, so if the proper rates are applied Eurasian watermilfoil can be controlled with limited damage to the majority of native species. However, fluridone must be used at higher rates to obtain control of Brazilian elodea, thus increasing the damage to many of the native species which are present in Griffy Lake.

Triclopyr is a systemic herbicide that has recently been approved for use in aquatics. This herbicide is typically used for treating isolated milfoil beds as opposed to whole lake treatments. Triclopyr is very selective to Eurasian watermilfoil and would have no effect on Brazilian elodea or curlyleaf pondweed.

Applied properly, 2,4-D can also yield major reductions in the abundance of Eurasian watermilfoil, but long-term reductions are more difficult to achieve using 2,4-D than using whole-lake fluridone applications. This formulation should be used much like triclopyr, but the same results may not occur. Unlike triclopyr, 2,4-D can impact the native species coontail. However, this herbicide has no effect on Brazilian elodea and curlyleaf pondweed.

Contact herbicides can also be effective for controlling submersed vegetation in the short term. The three primary contact herbicides used for control of submersed vegetation are diquat (trade name Reward), endothall (trade name Aquathol), and copper based formulations (trade names Komeen, Nautique, and Clearigate).

Historically, a drawback to the use of contact herbicides has been the lack of selectivity exhibited by these herbicides. However, a study recently completed by Skogerboe and Getsinger outlines how endothal can be used for control of the exotic species curlyleaf pondweed and Eurasian watermilfoil with little effect on the majority of native species. They found early season treatments with endothall effectively controlled Eurasian watermilfoil and curlyleaf pondweed at several application rates with no regrowth eight weeks after treatment. Sago pondweed, eel grass, and Illinois pondweed biomass were also significantly reduced following the endothall application, but regrwoth was observed at eight weeks post-treatment. Coontail and elodea showed no effects from endothall at three of the lower application rates. Spatterdock, pickerel weed, cattail, and smartweed were not injured at any of the application rates (Skogerboe & Getsinger 2002). This type of treatment strategy could be applied to lakes that have large areas of both curlyleaf pondweed and Eurasian watermilfoil. Endothal could also be effective the year after whole lake sonar treatments where curlyleaf pondweed typically returns the following season. However, endothal has no effect on Brazilian elodea.

Diquat and the copper formulations are effective fast acting contact herbicides. Diquat and copper formulations are very effective at controlling Eurasian watermilfoil, Brazilian elodea, and curlyleaf pondweed. A small area near the Griffy Lake boat ramp was effectively treated for Brazilian elodea with diquat in 2004. Diquat provides a herbicide option where certain areas containing nuisance species can be treated while other areas containing native vegetation can be left untreated. The drawback to using these herbicides is their relatively short-term control. Annual contact herbicide treatments would have to take place two to three times a year in order to control these exotic species.

Table 6. Summary of Potential Vegetation Control Methods for Griffy Lake.

Control Method	Advantages	Disadvantages	Conclusion
No Action	No cost, less controversy	No plant control, degradation of fish habitat, difficult boating, and spread of exotics plant species.	Not an option due to presence of Brazilian elodea and potential spread.
Environmental Manipulation (drawdown)	Low cost, compaction of flocculent sediments, may get control of some nuisance species especially Brazilian elodea. Could be integrated with chemical control.	Unpredictable plant control, exposes desirable plants and animals to freezing and thawing, no control structure, dependent on good freeze, could impede recreation, dependent on spring rains to raise water level, and could lead to dissolved oxygen problems.	Has potential to be integrated with chemical control, but results are unpredictable and lack control structure at dam.
Mechanical (cutting, dredging, or tilling)	Low cost, less controversy, and one can target areas of desired control, removes organics.	Possibility of spreading exotic vegetation, labor intensive, damage to fish and other aquatic organisms, and harvesting can promote increased milfoil and Brazilian elodea growth.	Not good option due to potential spread of exotics. Could possibly be used on small-scale initial infestation or post-treatment.

Biological Control (milfoil weevil)	No chemical needed, naturally occurring native species, no use restrictions following application, selective for Eurasian watermilfoil, and known to cause fatal damage to plant	Studies have been inconclusive on the effectiveness and cost is relatively high compared to most other control methods. Will not control Brazilian elodea or curlyleaf pondweed	No proof that this method is effective. Too large of an investment for unproven method. Brazilian elodea is priority.
Biological Control (Grass Carp)	No chemical needed, no use restrictions following application, and proven to consume aquatic vegetation.	Prefers many of the many native species over exotic species, non-native fish species, tend to move downstream, once they are introduced they are nearly impossible to remove.	Not a good option due to inability to remove once stocked.
Chemical Control	Proven safe and effective technique, can be selective, relatively easy application, and fast results.	Higher cost than most techniques, public concern over chemicals, build-up of dead plant material following application, and lake use restrictions	Best option, proven to be effective & minimal use restrictions with fluridone.

Action Plan

The 2004 Griffy Lake plant sampling revealed the presence of three exotic species: curlyleaf pondweed, Eurasian watermilfoil, and Brazilian elodea. It is important to formulate an action plan to control all three of these species, however, precedent should be placed upon controlling and/or eradicating Brazilian elodea. This species is relatively new to the state of Indiana and has the potential to spread to other waterbodies. A good number of waterbodies within this state already suffer from the introduction of the exotic species Eurasian watermilfoil and curlyleaf pondweed. Adding another, potentially more aggressive and more difficult to control species, could be detrimental to native plant communities and fisheries. We are fortunate that this potential invasion has been discovered and seems to be isolated to a single public reservoir. Steps must be taken to stop the invasion in its tracks. Several different management options have been discussed. From these management options we formulated three potential action plans; precision whole-lake fluridone treatment, whole lake fluridone treatment, and annual diquat applications. These different action plans were presented to the public and the Bloomington Department of Parks and Recreation at a November meeting. After much discussion it was agreed to pursue the precision whole-lake fluridone treatment. In conjunction with this treatment, an inspection of the sluice gate and an engineering feasibility study should be completed to allow for future lake drawdowns. Lake drawdown may help reduce the amount of herbicide needed for future nuisance vegetation control.

Precision whole-lake fluridone treatment
A whole lake fluridone treatment would produce the most effective control of exotic species, especially Brazilian elodea. This treatment alone may not eliminate exotic species, but at least 80% control should occur by mid-summer if treatment takes place in early spring. Intense sampling should take place prior to and following this treatment. In following years, if any Brazilian elodea is discovered it should be treated with diquat herbicide or physically removed by experienced divers. The area near the boat ramp should be closely monitored and additional treatment should take place if any Brazilian elodea is discovered.

There are several steps that should be taken prior to initiating a fluridone treatment in order to improve dose accuracy and reduce damage to native vegetation. These steps are the difference between what we call the "Precision whole-lake fluridone treatment" and the "whole lake fluridone treatment".

1. Average flow data should be calculated for Griffy Creek in order to calculate the amount of dilution that would occur.
2. A more current bathymetric map should be created to allow for more precise volume calculations.
3. PlanTEST's should be completed on Brazilian elodea in order to obtain a more accurate dosage recommendation. This testing will determine the lowest fluridone concentration needed to effectively control the targeted species.
4. Once the fluridone is applied concentrations should be monitored using FasTESTs. FasTESTs are used to obtain an actual fluridone concentration from treated water. This will allow an applicator the ability to maintain the proper fluridone level. Plant damage can also be monitored with an EffecTEST. This will determine how the targeted plants are being effected by the treatment.

These steps will add additional costs and may cause a delay of up to one year before a fluridone treatment is initiated. If these additional steps are taken, and a fluridone treatment cannot be initiated in 2005, diquat should be used to at least control the Brazilian elodea in the boat ramp area. The initial cost of this type of treatment will be high, but will decrease in following years. Additional fluridone treatments may be needed every 3-8 years depending on the effectiveness of the initial treatment and ability to control exotic species with annual contact treatments.

Plant sampling should take place in years following the fluridone treatment in order to assess the treatment's effectiveness and to identify any areas which may still contain exotic species. Ideally a Tier I survey and a pair of Tier II surveys should be completed each season in order to monitor the effects of the management action. This data will be valuable when assessing future plant management activities in Griffy Lake. Along with the detailed plant sampling, experienced park personnel should visually monitor the aquatic vegetation on at least a monthly basis. In addition to sampling within Griffy Lake, the Indiana Department of Natural Resources should consider sampling below the dam in Griffy Creek. It is possible that Brazilian elodea has traveled down-stream and infested additional bodies of water.

If Brazilian elodea is discovered following the whole lake fluridone treatment, it should be quickly treated with diquat herbicide or manually removed by experienced divers. The sluice gate should also be fixed so that winter drawdown can be used as an alternative control technique. Drawdown may help control Brazilian elodea in the shallow boat ramp area.

The major drawbacks of a whole-lake fluridone treatment involve possible impact on native non-target aquatic plants. The native species coontail, brittle and slender naiad, and sago pondweed may be damaged by this treatment. Their populations should be closely monitored following this treatment and a planting program should be initiated if recovery does not take place within two-years post treatment.

Table 7 is an estimated budget for the precision whole-lake fluridone treatment. The herbicide application cost figures in a theoretical 30 parts-per-billion dose of Sonar Q herbicide. A more accurate dose should be figured following the PlanTEST, which is designed to figure the lethal dose of fluridone necessary to kill selected species. An accurate bathymetric map and volume calculation will also be needed to figure a more accurate dose. The cost of a 2-foot interval bathymetry and volume map would be approximately $12,930. Treatment should be completed in late March or April before Brazilian elodea starts actively growing. Following an initial fluridone treatment the concentration will be monitored using the FasTEST. Necessary “bump” applications can be made based on test results. EffecTESTs should also be completed prior to bump applications. This test is used to diagnose the effects the herbicide is having on the targeted vegetation. Vegetation sampling should be completed at least twice during the treatment season and twice a year for at least the next four years in order to monitor the effects of the whole lake treatment. It is hard to predict the exact amount of Brazilian elodea that may return in following years, but Table 7 contains a rough estimate of the funding which may be needed to treat remaining plants. If only a few plants remain it may be possible to physically remove them with experienced divers.

Table 7. Budget estimates for management options

Precision whole-lake fluridone treatment and follow-up diquat applications

	2005	**2006**	**2007**	**2008**
Herbicide & Application Cost	$50,000	$4,000	$6,000	$8,000
Vegetation Sampling & Plan Update	$3,500	$3,500	$3,500	$3,500
Bathymetric map and volume calc.	$12,930	-	-	-
PlanTEST	$3,000	-	-	-
EffecTEST	$1,500	-		-
FasTEST	$1,500	-	-	-
Total:	**$72,430**	**$7,500**	**$9,500**	**$11,500**

Despite the potential damage to native vegetation, it is Aquatic Control's belief that the Precision Fluridone Treatment is the best plan of action for controlling exotic species, especially Brazilian elodea, in Griffy Lake.

Education

It is important that all lake users and other stakeholders participate and be informed about the lake management activities. A public meeting was conducted November 29, 2004 at the Showers Council Chambers in Bloomington Indiana. This meeting was used to obtain public input and support of the vegetation management plan. A Lake Use Survey was distributed at the meeting and eleven lake users filled out the form. The results of this survey are listed in Appendix D. Overall, it was apparent that those in attendance agreed that steps needed to be taken to control Brazilian elodea. A second meeting should also be scheduled to discuss the final plan. Each winter a meeting should take place to discuss necessary changes in the plan and to update lake users of changes and activities. It is very important that signs be posted around the lake and especially at the boat ramp warning lake users about the transport of exotic species, especially Brazilian elodea. Signs should also be posted with a brief description of the management activities which are taking place or are scheduled to take place. Additional information concerning aquatic vegetation management can be obtained at the following web sites: www.mapms.org, www.aquatics.org, www.apms.org, www.aquaticcontrol.com, and www.nalms.org .

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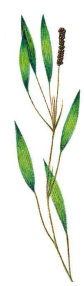
Appendix A. Macrophyte List for Griffy Lake

Common Name	Scientific Name	Tier I '04	Tier II '04	DNR '04	Scribalio '03
American Pondweed	*Potamogeton nodosus*	X	X		
American Water Willow	*Justica americana*	X			
Brazilian Elodea	*Myriophyllum spicatum*	X	X	X	X
Brittle Naiad	*Najas minor*	X	X	X	
Creeping Water Primrose	*Ludwigia peploides*	X		X	
Chara	*Chara sp.*	X	X	X	
Common Cattail	*Typhia latifolia*	X			X
Common Coontail	*Ceratophyllum demersum*	X	X	X	X
Curlyleaf Pondweed	*Potamogeton crispus*	X	X	X	X
Duckweed Sp.	*Lemna sp.*	X			X
Eurasian Watermilfoil	*Myriophyllum spicatum*	X	X	X	X
Horned Pondweed	*Zannichellia palustris*			X	X
Illinois Pondweed	*Potomogeton illinoensis*				X
Marsh Purslane	*Ludwigia palustris*				X
Pickeral Weed	*Pontederia cordata*				X
Sago Pondweed	*Potomogeton pectinatus*	X	X	X	X
Slender Naiad	*Najas flexilis*	X	X		X
Small Pondweed	*Potamogeton pusillus*	X	X		X
White Water Lily	*Nymphaea tuberosa*				X
Yellow Pond Lily	*Nuphar advena*				X



American Pondweed (Potamogeton nodosus) is a perennial herb that often times is referred to as longleaf pondweed. Contains submersed and floating leaves. Occupies shallow water. Occurs throughout North America. Reproduces through rhizomes and seeds.

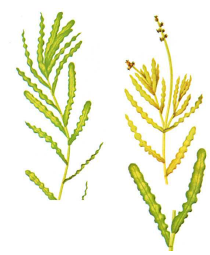
American Water Willow (*Justica americana*)is a perennial herb, spreading by rhizomes and sometimes forming large colonies. Stems are usually unbranched and smooth. Leaves are opposite, linear to lance-shaped, and tapered to a tip. Inhabits shallow water, muddy pond and lakeshores, and mud bars[2]. Considered good fish cover, especially for largemouth bass.

Brazilian Elodea (*Egeria densa*) is an exotic submersed perennial herb that spreads through stem fragments. Sometime referred to as anacharis, Brazilian egeria, egeria, Brazilian waterweed, and leafy elodea. Introduced from Brazil in early 1900's. Now located throughout the southeast U.S., west coast, and Hawaii. Forms dense monoculture plant beds. Populations in United States consist of only male plants.

Chara (*chara sp.)* is anchored green algae with whorled, branchlike filaments at the nodes of a central axis. Often times mistaken for vascular plants. Typically inhabits shallow water. Provide food and cover for wildlife. Rarely reaches the surface of the water and rarely causes problem.

Common coontail (*Ceratophylum demersum*) is a commonly occurring aquatic plant in the Midwest in neutral to alkaline waters[1]. It is a submersed dicot with coarsely toothed leaves whorled about the stem[2]. This plant is given its name due to its resemblance to the tail of a raccoon. Coontail has been found to be an important food source for wildfowl as well as a good shelter for small animals[2]. This plant is also a good shelter for young fish, and support of insects[2], but has been known to crowd out other species of aquatic plants[3].

Curlyleaf pondweed (*Potamogetan crispus*) is a submersed monocot with slightly clasping, rounded tip leaves. The flowers occur on dense cylindrical spikes and produces distinctive beaked fruit[1]. Curly leaf is eaten by ducks, but may become a weed[2]. This plant provides good food, shelter, and shade for fish and is important for early spawning fish like carp and goldfish[2].



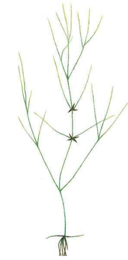
Eurasian water-milfoil (*Myriophyllum spicatum*) is an exotic aquatic plant that has been known to crowd out native species of plants. This species spreads quickly because it can grow from very small plant fragments and survive in low light and nutrient conditions[3]. This dicot has stems that typically grow to the water surface and branch out forming a canopy that shades other species of aquatic plants. Eurasian water-milfoil has characteristic red to pink flowering spikes that protrude from the water surface one to two inches high[1]. The segmented leaves grow in whorls of three to four around the stem[1]. This exotic plant is easily differentiated from its native relative, northern milfoil, by stem growth and the numbers of sections per leaf.

---

[1] Chadde, S. 1998. Great lakes wetland flora. Pocketflora Press, Calumet, Michigan.

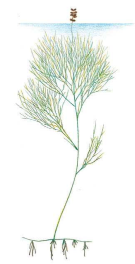
[2] Fassett, N. 1957. A manual of aquatic plants, 2nd edition. The University of Wisconsin Press, Madison, Wisconsin.

[3] Applied Biocehmists, 1998. Water weeds and algae, 5th edition. Applied Biochemists, J. C. Schmidt and J. R. Kannenberg, editors. Milwaukee, Wisconsin.



Horned pondweed (*Zannichellia palustris*) is a common perennial aquatic herb with creeping rhizome and often forming extensive underwater mats. Flowers are small, produced underwater, either male or female, and separate on plant but from the same leaf axil. Plant usually common in spring and senesces in summer.

Small pondweed (*Potamogetan pusillus*) is a submersed monocot with slender, long leaves. Its fruit is green to brown and has a flat beak[1]. This plant provides fish with good cover and food and is a good food source for wildfowl[2]. This species has a propensity for developing nuisance conditions when competition from other species is not present.



Sago pondweed (*Stuckenia pectinata*) is a submersed monocot with leaves that are threadlike to narrowly linear that form a sheath around the stem[1]. The nutlet and tubers of this plant make it the most important pondweed for ducks[2]. It also provides food and shelter for young trout and other fish[2]. This species can produce thick nuisance growth in shallow near-shore areas of lakes.

White water lily (*Nymphaea odorata*) is a floating attached dicot that grows from tubers and produces broad, deeply lobed floating leaves and white flowers[1]. This plant produces seed that is fair food for wildfowl[2]. The root stocks and petiole bases are eaten by muskrats and the "roots" are eaten by beaver, deer, moose, and porcupine[2]. White water lilies can provide good habitat for fish, but can induce a negative value when too dense[2].

Yellow pond lily (*Nuphar advena*) is an emergent dicot with broad, deeply lobed leaves emerging from the water[1]. This plant has distinctive large yellow flowers emanating from spikes. Yellow pond lily produces seeds and rootstocks that are used by wildfowl, beaver, moose and porcupine[2]. This plant attracts wildfowl and marsh birds and the bases of the petioles are eaten by muskrats[2]. Yellow pond lilies are a poor producer of food for fish, but provide good shade and shelter[2].

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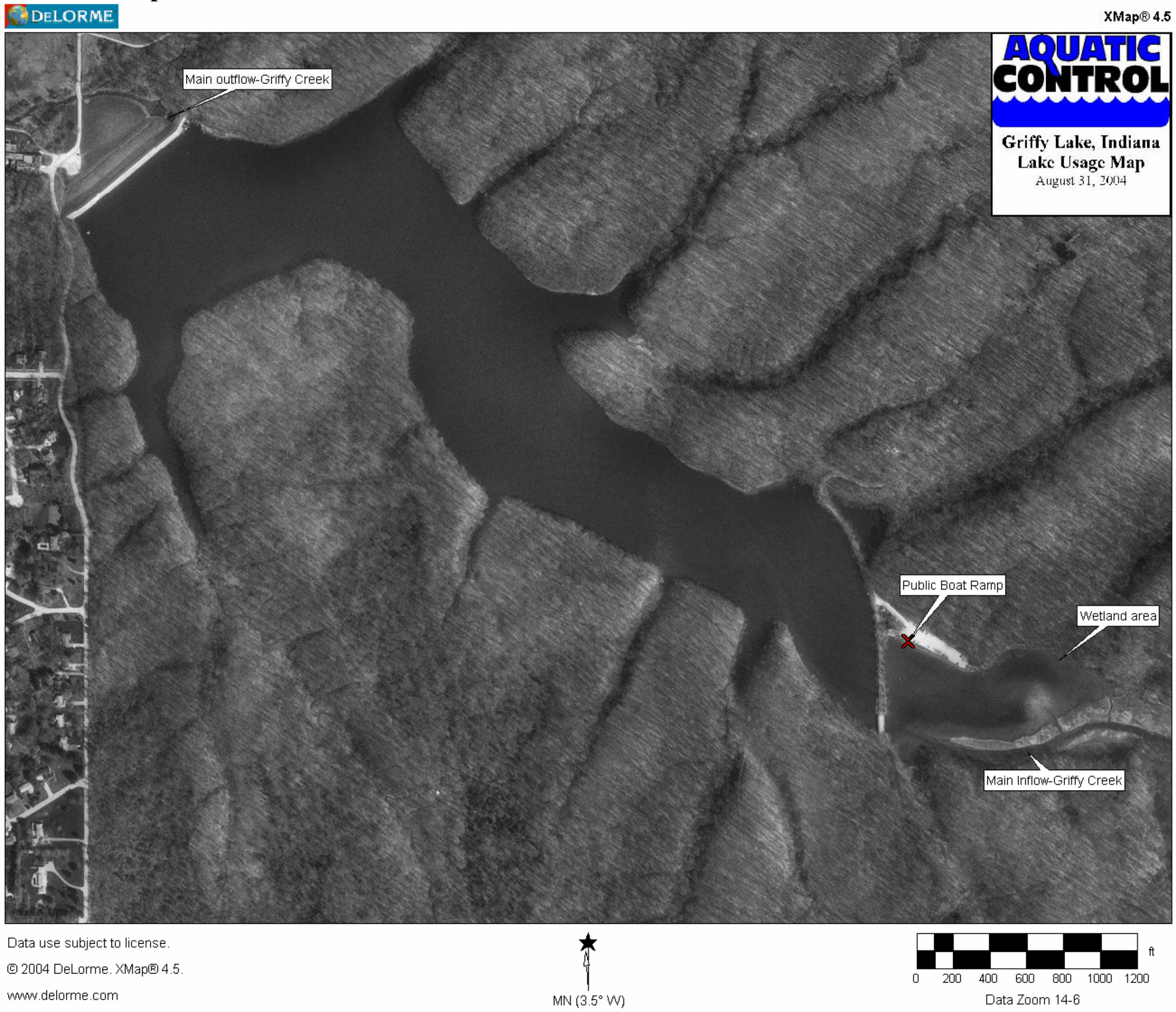
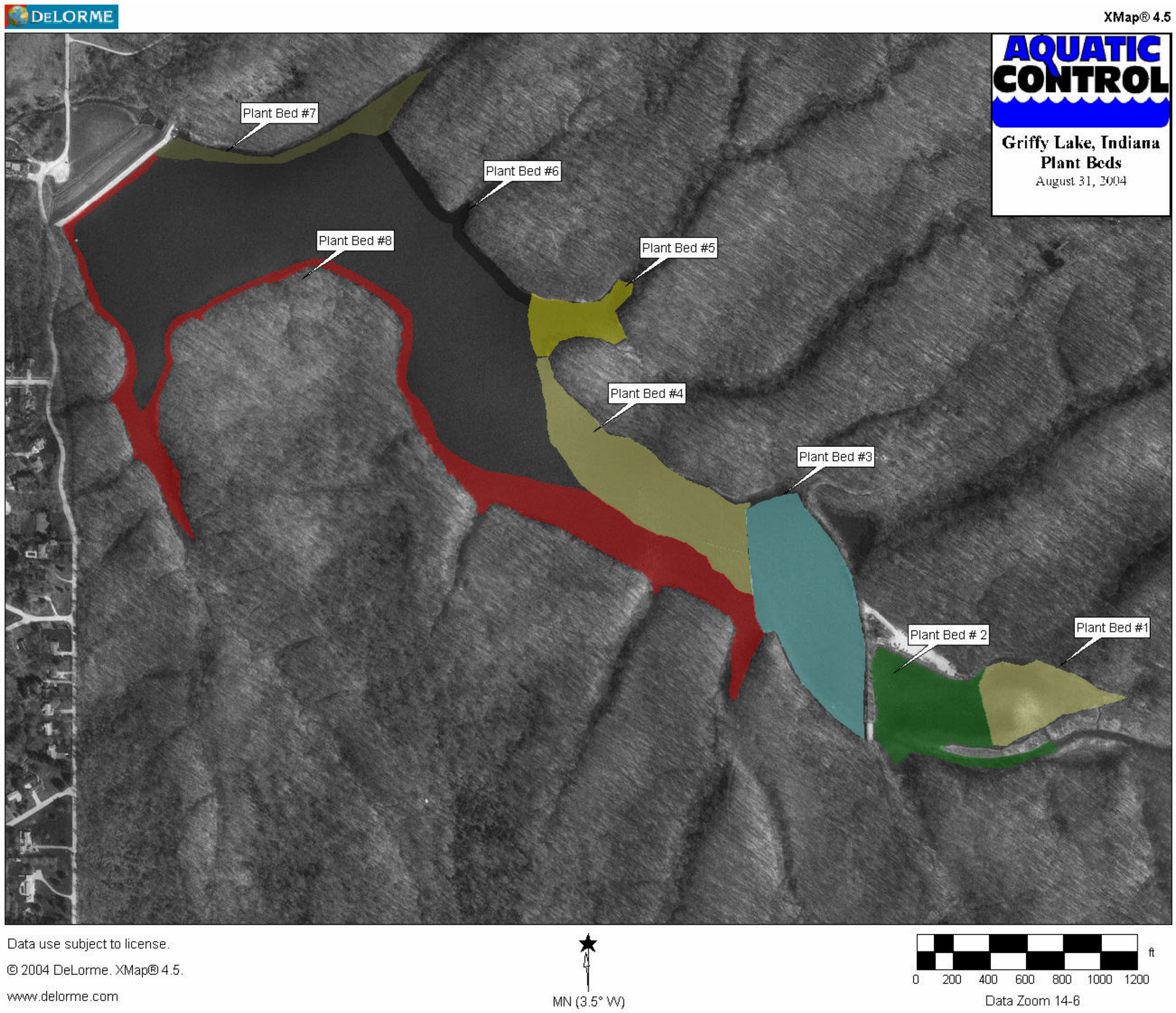
[1] Chadde, S. 1998. Great lakes wetland flora. Pocketflora Press, Calumet, Michigan.

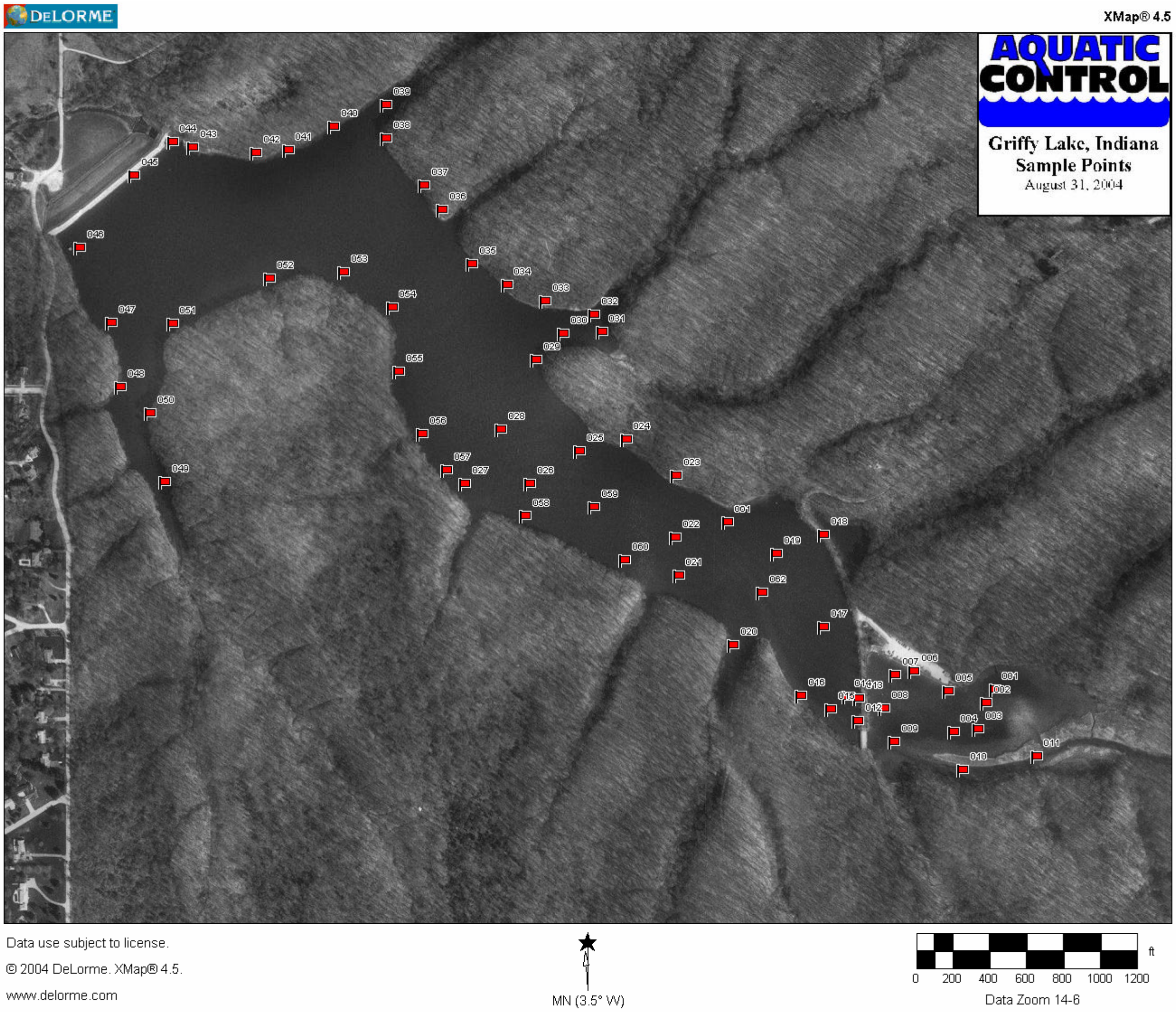
[2] Fassett, N. 1957. A manual of aquatic plants, 2nd edition. The University of Wisconsin Press, Madison, Wisconsin.

[3]Applied Biocehmists, 1998. Water weeds and algae, 5th edition. Applied Biochemists, J. C. Schmidt and J. R. Kannenberg, editors. Milwaukee, Wisconsin.

Appendix B. Maps




DeLorme
XMap® 4.5
AQUATIC CONTROL
Griffy Lake, Indiana
Plant Beds
August 31, 2004
Plant Bed #7
Plant Bed #6
Plant Bed #8
Plant Bed #5
Plant Bed #4
Plant Bed #3
Plant Bed # 2
Plant Bed #1
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.5° W)
0 200 400 600 800 1000 1200 ft
Data Zoom 14-6


DELORME
XMap® 4.5
AQUATIC CONTROL
Griffy Lake, Indiana
Sample Points
August 31, 2004
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.5° W)
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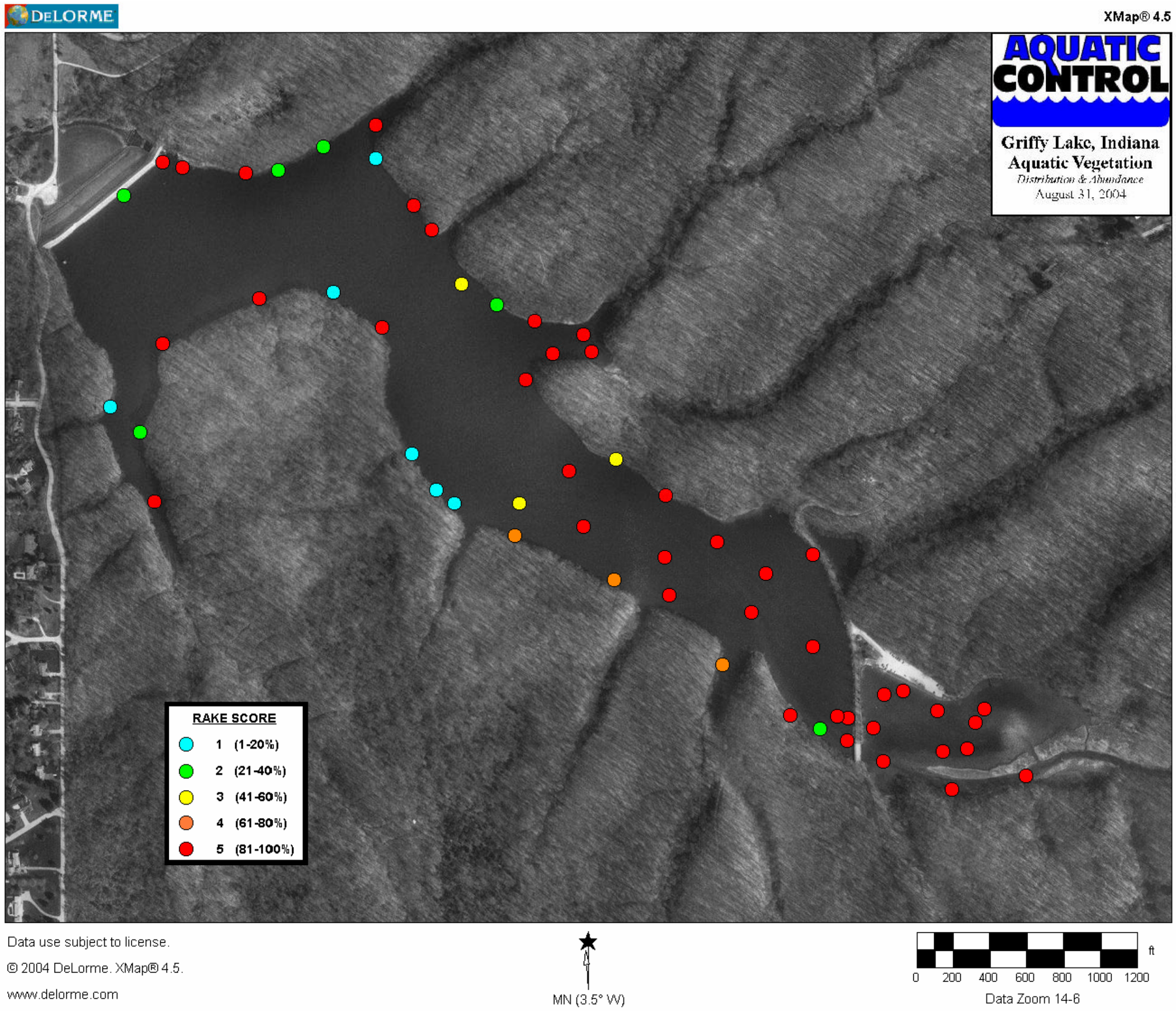
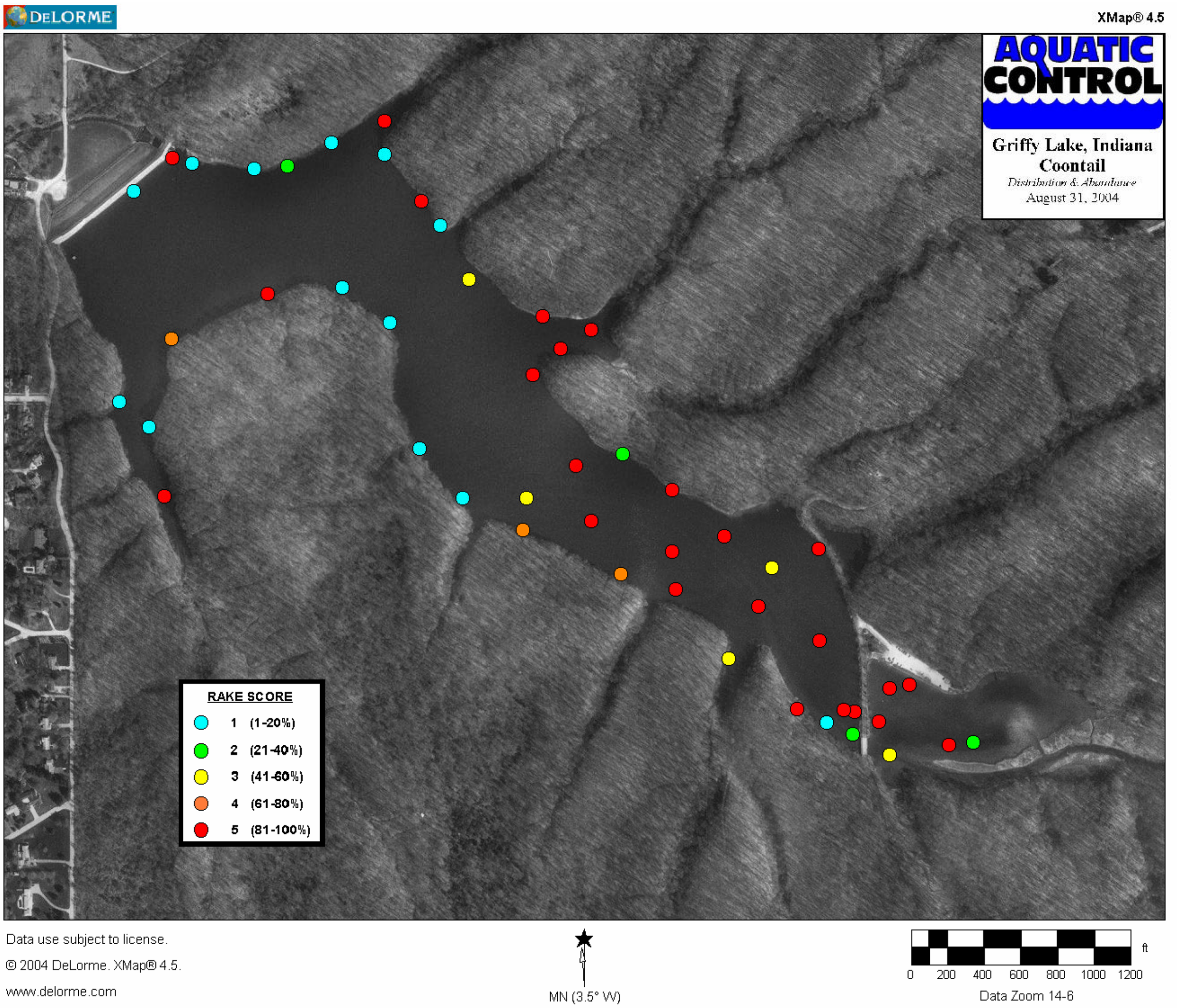
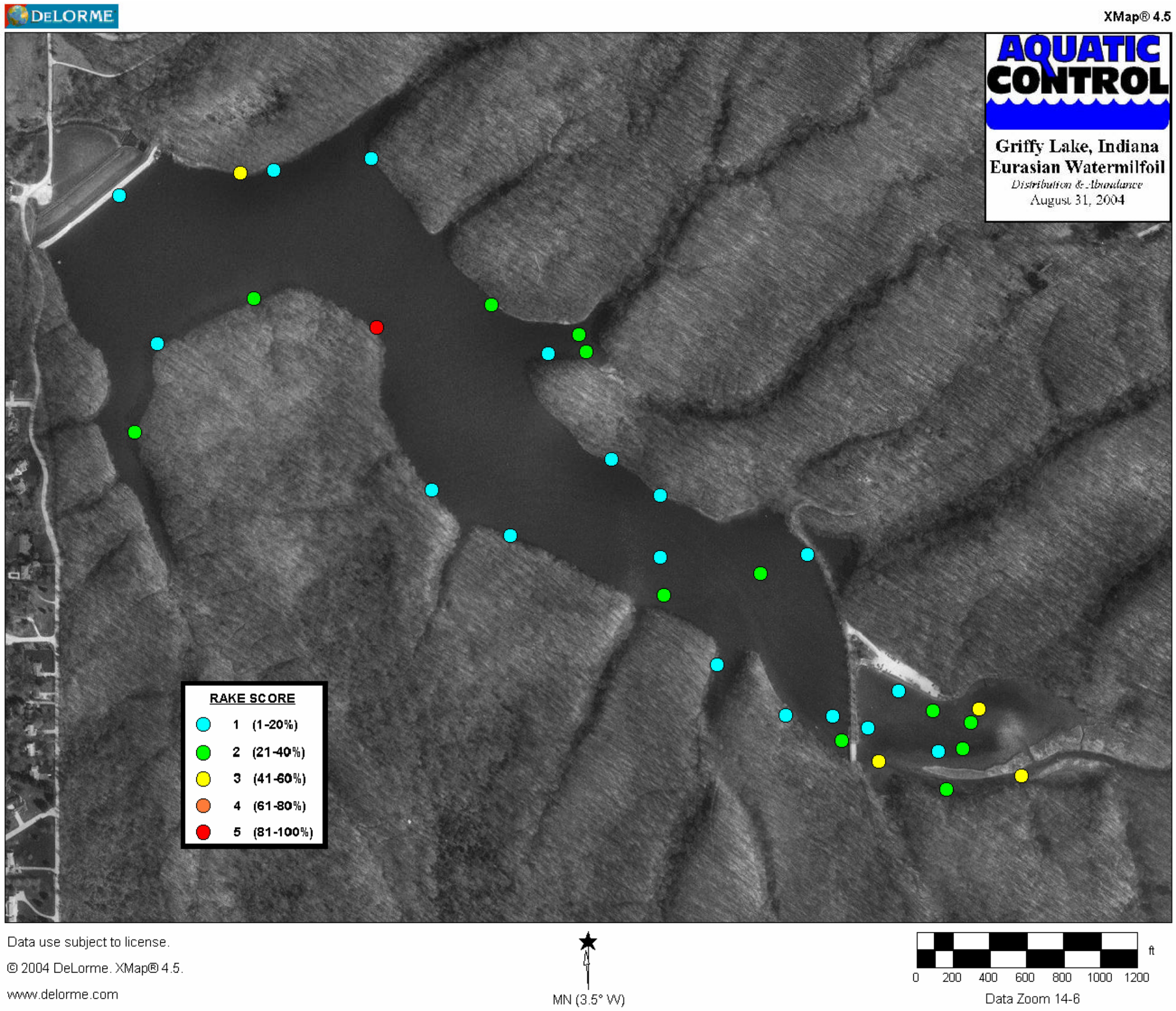
ft
Data Zoom 14-6


DELORME
XMap® 4.5
AQUATIC CONTROL
Griffy Lake, Indiana
Aquatic Vegetation
Distribution & Abundance
August 31, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.5° W)
ft
0 200 400 600 800 1000 1200
Data Zoom 14-6


DELORME
XMap® 4.5
AQUATIC CONTROL
Griffy Lake, Indiana
Coontail
Distribution & Abundance
August 31, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.5° W)
0 200 400 600 800 1000 1200 ft
Data Zoom 14-6


DeLORME
XMap® 4.5
AQUATIC CONTROL
Griffy Lake, Indiana
Eurasian Watermilfoil
Distribution & Abundance
August 31, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.5° W)
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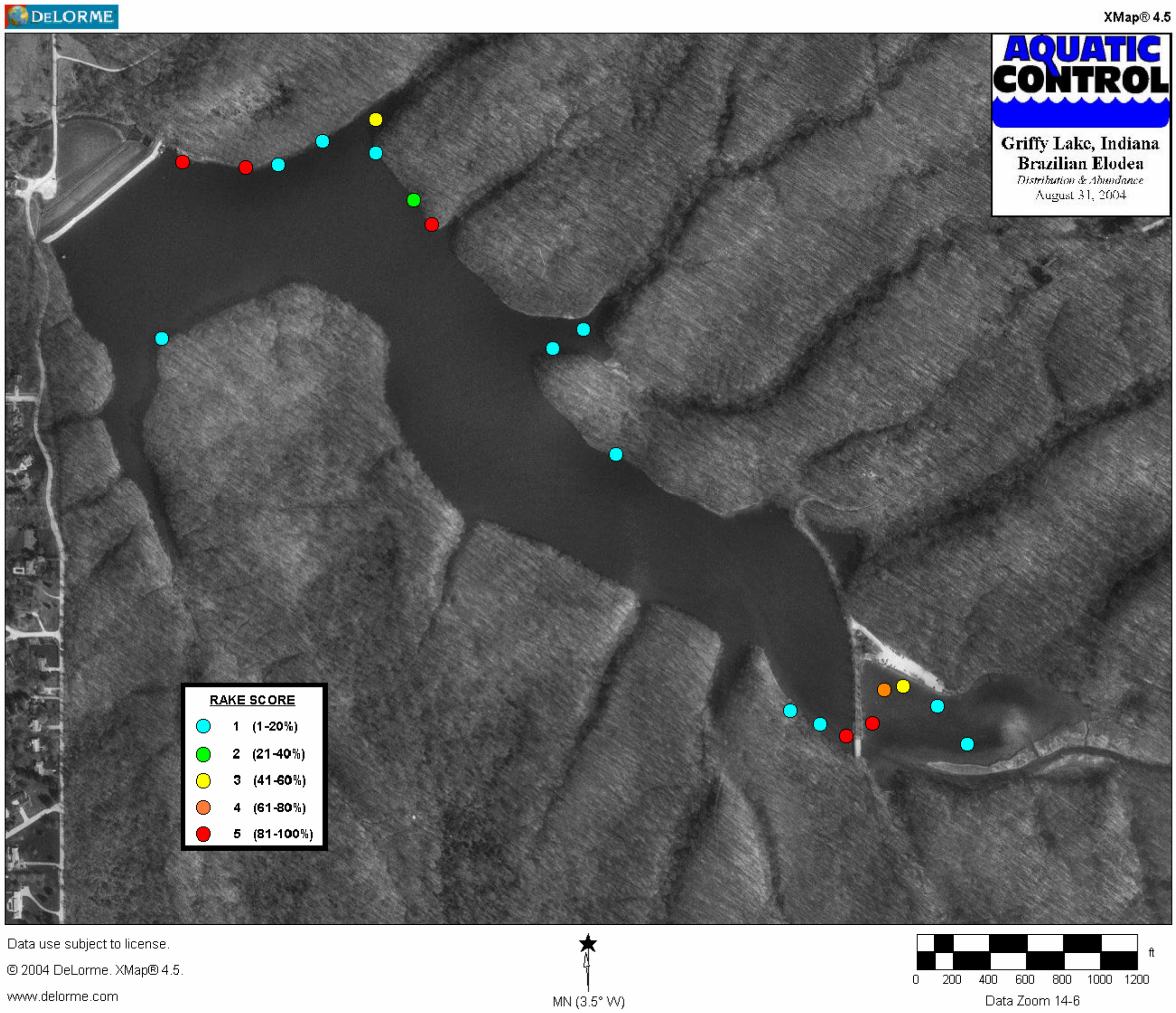
ft
Data Zoom 14-6


DeLORME
XMap® 4.5
AQUATIC CONTROL
Griffy Lake, Indiana
Brazilian Elodea
Distribution & Abundance
August 31, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
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www.delorme.com
MN (3.5° W)
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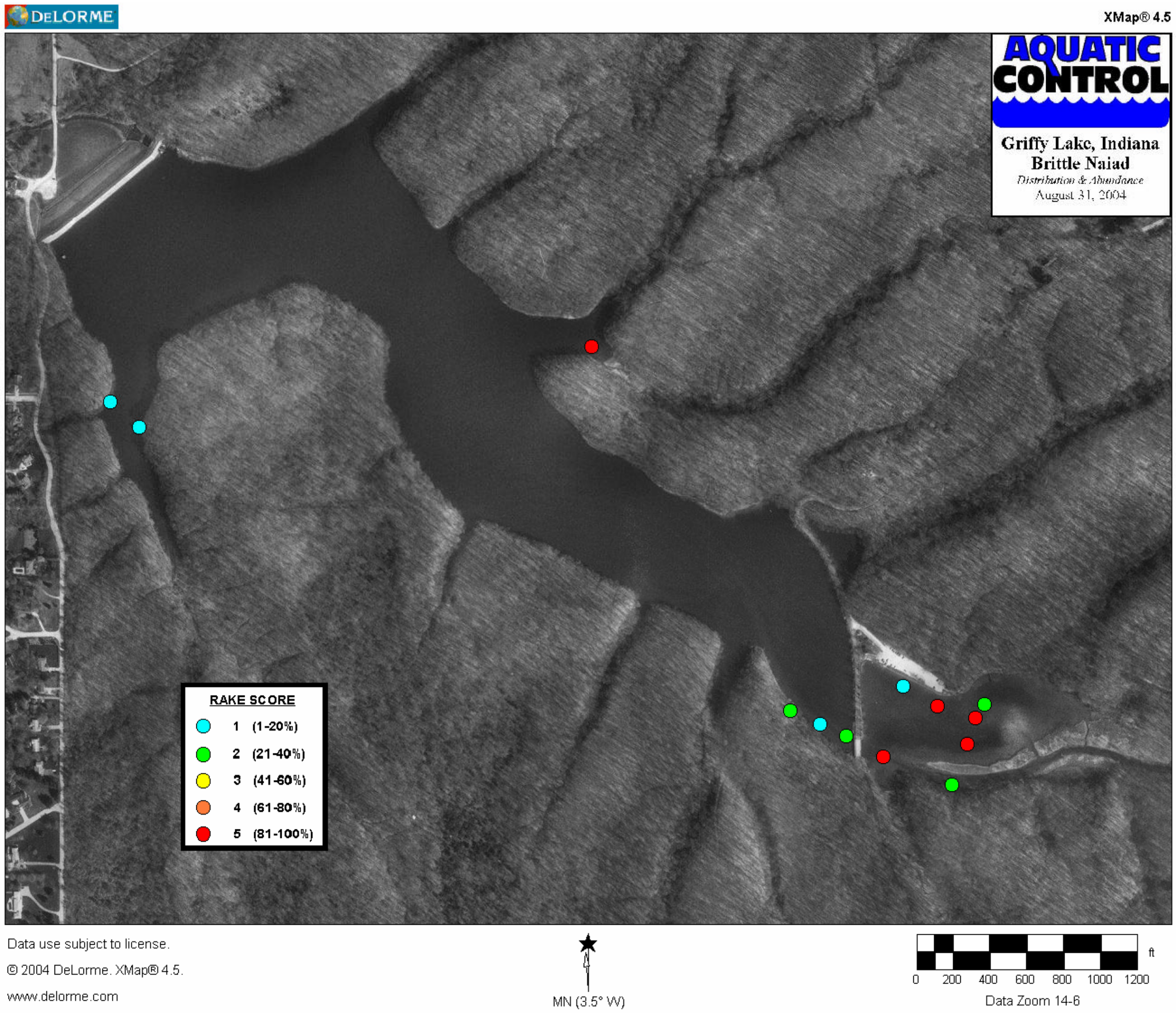
ft
Data Zoom 14-6


DELORME
XMap® 4.5
AQUATIC CONTROL
Griffy Lake, Indiana
Brittle Naiad
Distribution & Abundance
August 31, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
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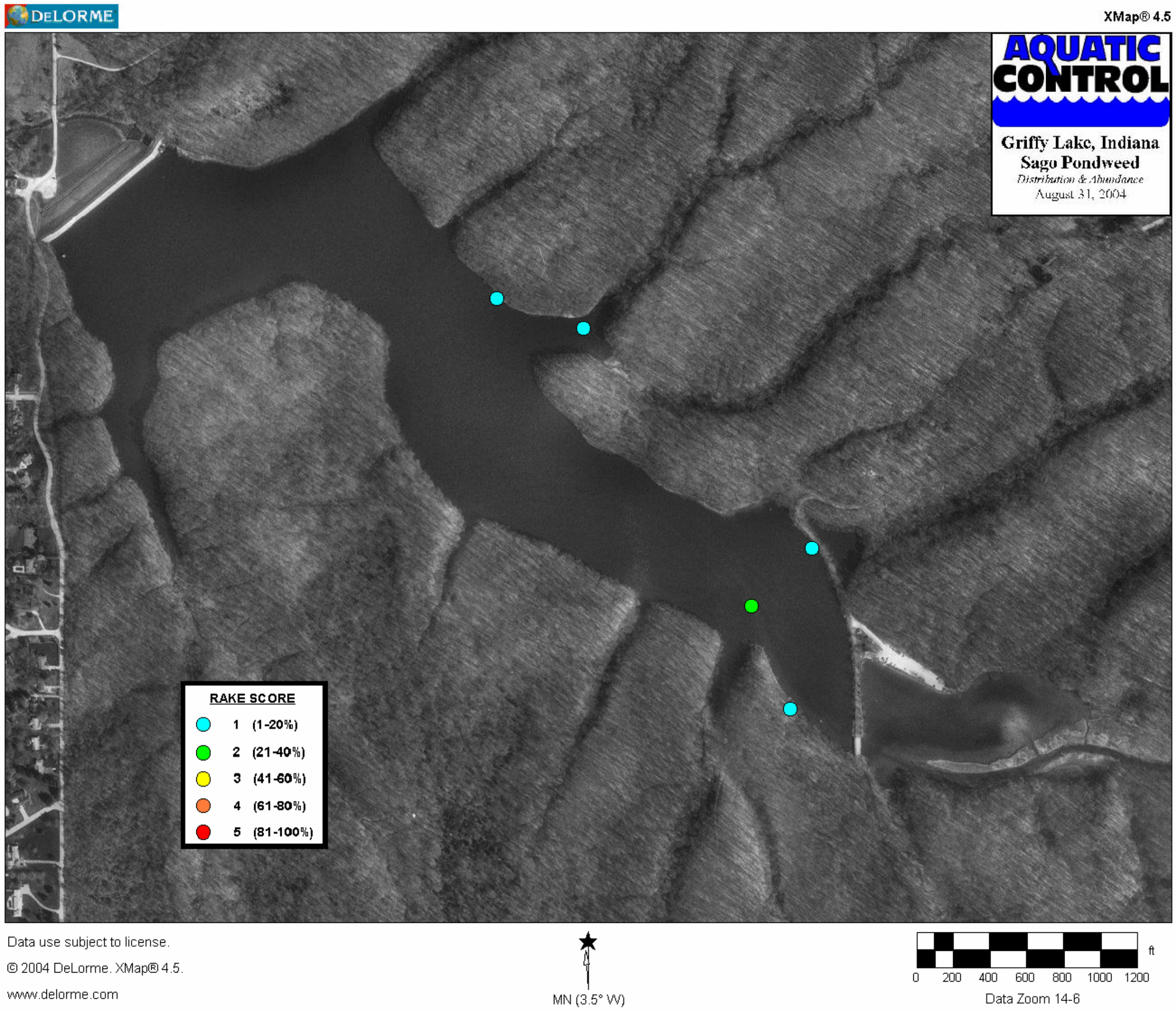
MN (3.5° W)
ft
0 200 400 600 800 1000 1200
Data Zoom 14-6


DeLORME
XMap® 4.5
AQUATIC CONTROL
Griffy Lake, Indiana
Sago Pondweed
Distribution & Abundance
August 31, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
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MN (3.5° W)
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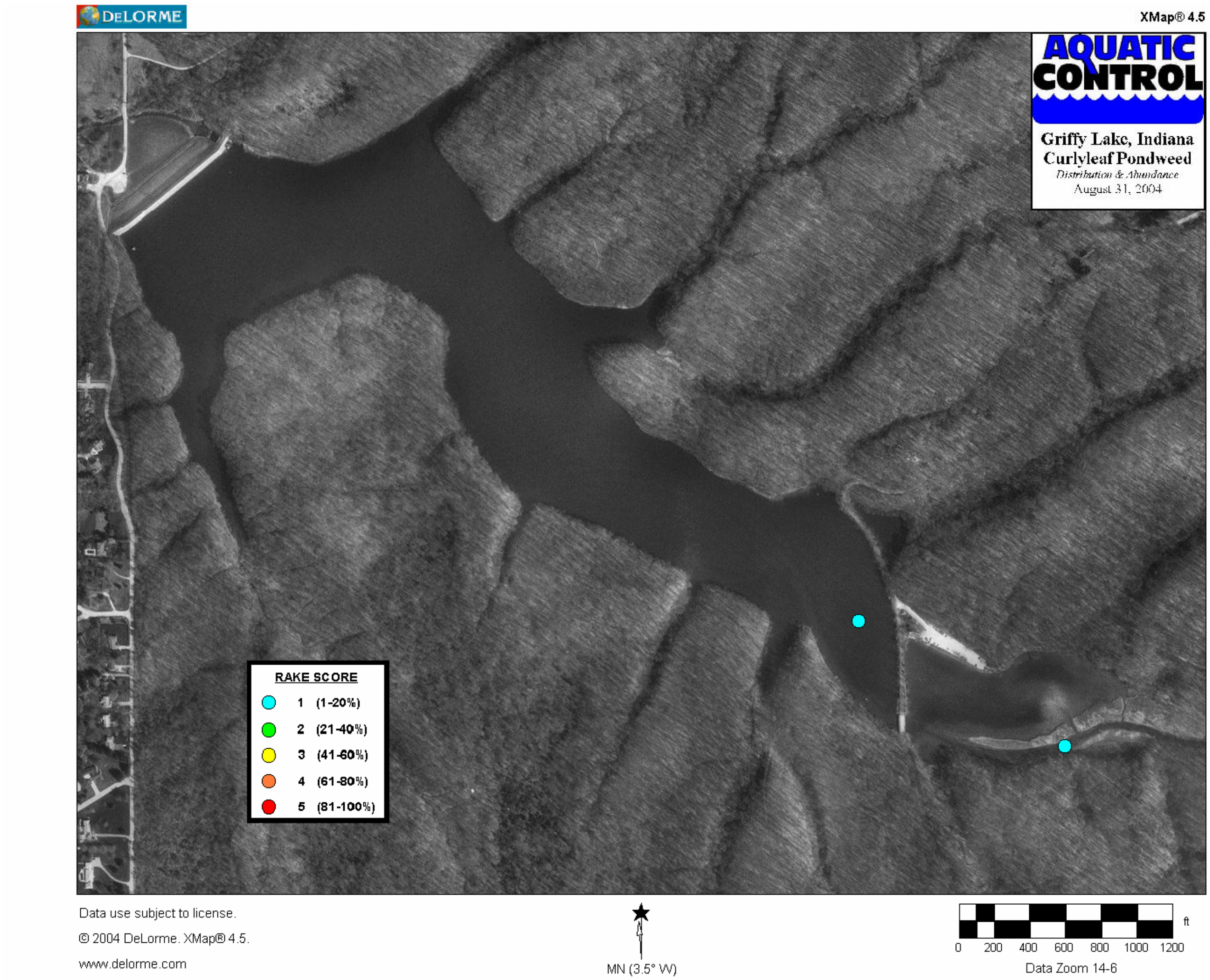
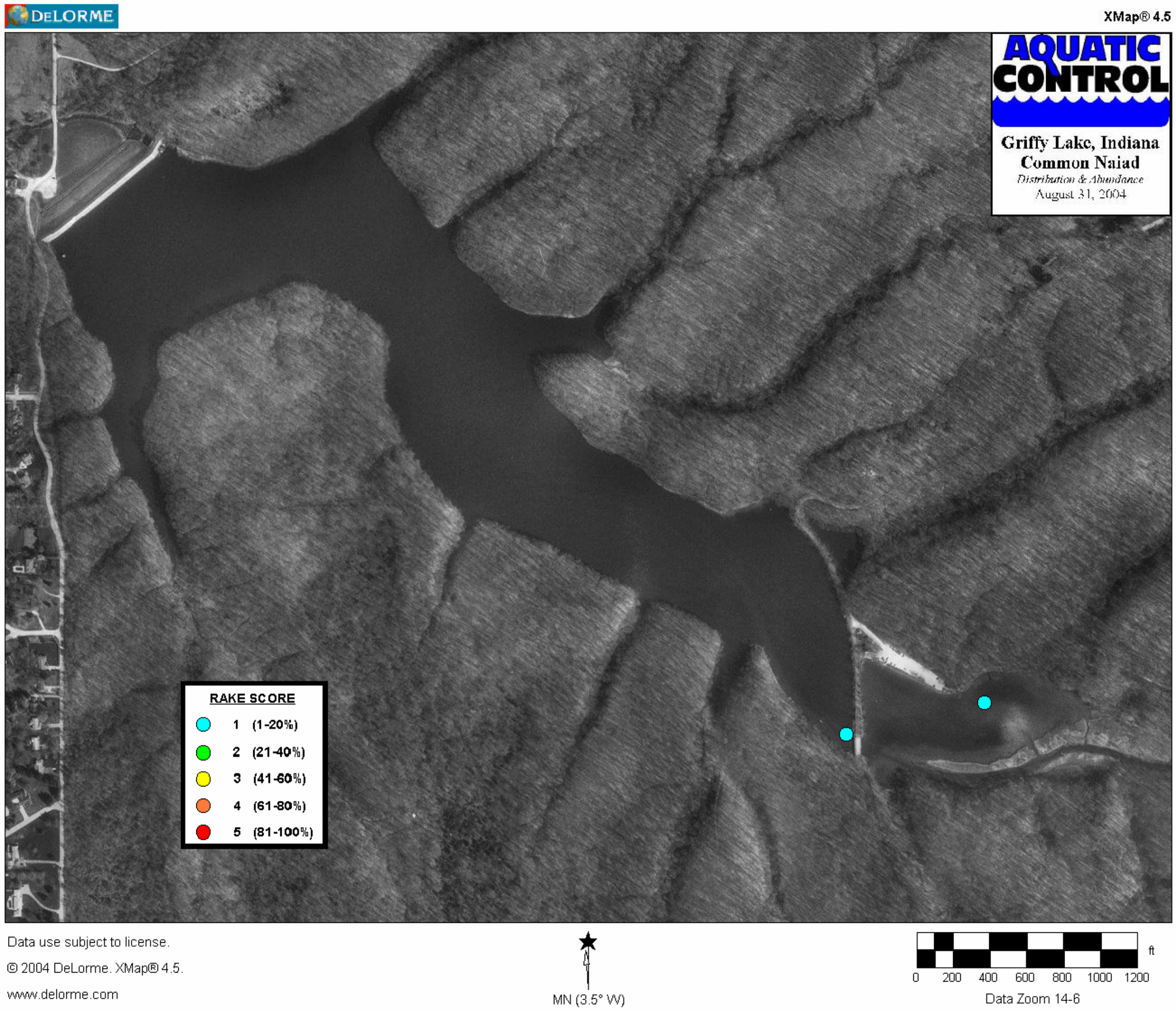
Data Zoom 14-6


DELORME
XMap® 4.5
AQUATIC CONTROL
Griffy Lake, Indiana
Curlyleaf Pondweed
Distribution & Abundance
August 31, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.5° W)
0 200 400 600 800 1000 1200
ft
Data Zoom 14-6


DELORME
XMap® 4.5
AQUATIC CONTROL
Griffy Lake, Indiana
Common Naiad
Distribution & Abundance
August 31, 2004
RAKE SCORE
1 (1-20%)
2 (21-40%)
3 (41-60%)
4 (61-80%)
5 (81-100%)
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
www.delorme.com
MN (3.5° W)
0 200 400 600 800 1000 1200
ft
Data Zoom 14-6

Lake	Date	Latitude	Longitude	Site	Depth	RAKE	MYSP2	POCR3	CEDE4	CH?AR	NAMI	NAFL	POPE6	POPU7	PONO2	EGDE	ALGA	SppNum	NatSppNum
Griffey	8/31/04	39.19947	-86.51623	1	2.0	5	3				2	1					1	3	2
Griffey	8/31/04	39.19227	-86.51639	2	1.0	5	2				5							2	1
Griffey	8/31/04	39.19367	-86.51115	3	2.0	5	2		2		5					1		4	3
Griffey	8/31/04	39.19621	-86.51182	4	3.0	5	1		5									2	1
Griffey	8/31/04	39.19744	-86.51182	5	3.0	5	2				5					1		3	2
Griffey	8/31/04	39.19773	-86.51258	6	4.0	5	1		5		1					3		4	3
Griffey	8/31/04	39.19749	-86.51275	7	6.0	5			5							4		2	2
Griffey	8/31/04	39.19713	-86.51286	8	3.0	5	1		5							5		3	2
Griffey	8/31/04	39.19633	-86.51276	9	2.0	5	3		3		5						1	3	2
Griffey	8/31/04	39.19522	-86.51145	10	2.0	5	2			5	2							3	2
Griffey	8/31/04	[illegible]	[illegible]	11	2.0	5	3	1		5							1	3	1
Griffey	8/31/04	39.19638	-86.51847	12	6.0	5	2		2		2	1		1		5		6	5
Griffey	8/31/04	39.19763	-86.51943	13	4.0	5			5									1	1
Griffey	8/31/04	39.19485	-86.51904	14	5.0	5	1		5									2	1
Griffey	8/31/04	39.19517	-86.51537	15	8.0	2			1		1					1		3	3
Griffey	8/31/04	39.19747	-86.51434	16	7.0	5	1		5		2		1			1		5	4
Griffey	8/31/04	39.19924	-86.51442	17	8.0	5		1	5									2	1
Griffey	8/31/04	39.19876	-86.51412	18	6.0	5	1		5				1					3	2
Griffey	8/31/04	39.19943	-86.51592	19	10.0	5	2		3									2	1
Griffey	8/31/04	39.19912	-86.51586	20	5.0	4	1		3									2	1
Griffey	8/31/04	39.19716	-86.51653	21	11.0	5	2		5									2	1
Griffey	8/31/04	39.19972	-86.51606	22	14.0	5	1		5									2	1
Griffey	8/31/04	[illegible]	[illegible]	23	5.0	6	1		5						2			3	2
Griffey	8/31/04	39.20119	[illegible]	24	8.0	3	1		2							1		3	2
Griffey	8/31/04	39.20171	[illegible]	25	17.0	5			5									1	1
Griffey	8/31/04	[illegible]	[illegible]	26	16.0	3			3									1	1
Griffey	8/31/04	39.20154	-86.52139	27	14.0	1			1									1	1
Griffey	8/31/04	39.20164	-86.5200	28	22.0	0												0	0
Griffey	8/31/04	39.20267	-86.51966	29	16.0	5			5									1	1
Griffey	8/31/04	39.20276	[illegible]	30	6.0	5	1		5							1		3	2
Griffey	8/31/04	39.20278	-86.51937	31	2.0	5	2				5							2	1
Griffey	8/31/04	39.20364	-86.51652	32	3.0	5	2		5				1			1		4	3
Griffey	8/31/04	[illegible]	[illegible]	33	11.0	5			5									1	1
Griffey	8/31/04	39.20345	-86.52019	34	4.0	2	2						1					2	1
Griffey	8/31/04	39.20129	-86.52026	35	20.0	3			3									1	1
Griffey	8/31/04	[illegible]	-86.52142	36	10.0	5			1							5		2	2
Griffey	8/31/04	39.20160	-86.52170	37	5.0	5			5							2		2	2
Griffey	8/31/04	39.20566	-86.5225	38	8.0	1	1		1							1		3	2
Griffey	8/31/04	39.20115	-86.5225	39	8.0	5			5							3		2	2
Griffey	8/31/04	39.20569	-86.52672	40	14.0	2			1							1		2	2
Griffey	8/31/04	39.20546	-86.52468	41	8.0	2	1		2							1		3	2
Griffey	8/31/04	39.20345	-86.52501	42	3.0	5	3		1							5		3	2
Griffey	8/31/04	39.20752	-86.52621	43	14.0	5			1							5		2	2
Griffey	8/31/04	39.20651	-86.52659	44	11.0	5			5									1	1
Griffey	8/31/04	39.20011	-86.52784	45	7.0	2	1		1									2	1
Griffey	8/31/04	[illegible]	-86.52893	46	12.0	0												0	0
Griffey	8/31/04	39.20292	-86.52777	47	11.0	0												0	0
Griffey	8/31/04	39.20196	-86.52761	48	6.0	1			1		1							2	2
Griffey	8/31/04	39.20455	-86.52575	49	5.0	5			5									1	1
Griffey	8/31/04	39.20166	-86.52704	50	7.0	2	2		1		1							3	2
Griffey	8/31/04	39.20231	[illegible]	51	3.0	5	1		4							1		3	2
Griffey	8/31/04	39.20357	-86.52475	52	8.0	5	2		5									2	1
Griffey	8/31/04	39.20367	-86.52382	53	16.0	1			1									1	1
Griffey	8/31/04	39.20745	-86.52258	54	4.0	5	5		1									2	1
Griffey	8/31/04	[illegible]	-86.52227	55	7.0	0												0	0
Griffey	8/31/04	39.20125	-86.52192	56	12.0	1			1									1	1
Griffey	8/31/04	39.20072	-86.52134	57	8.0	1	1											1	0
Griffey	8/31/04	39.20095	-86.51582	58	10.0	4	1		4									2	1
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Griffey	8/31/04	39.19595	-86.51595	61	8.0	5			5									1	1
Griffey	8/31/04	39.19591	-86.51529	62	8.0	5			5				2					2	2

Species Codes	
BIBE	Bur marigold
CEDE4	Coontail
CH?AR	Chara
ELCA7	Elodea
LEMN	Duckweeds
MYHE	Broadleaf watermilfoil
MYSI	Northern watermilfoil
MYSP2	Eurasian watermilfoil
MYVE	Whorled watermilfoil
NAFL	Slender naiad
NAGU	Southern waternymph
NAMA	Spiny naiad
NAMI	Brittle waternymph
NELU	American lotus
NI?TE	Nitella
NOAQVG	No aquatic vegetation
NULU	Yellow pond lily
NYTU	White water lily
POAM	Large-leaf pondweed
POCR3	Curly-leaf pondweed
POFO3	Leafy pondweed
POGR8	Variable pondweed
POIL	Illinois pondweed
PONO2	American pondweed
POPE6	Sago pondweed
POPR5	White-stemmed pondweed
POPU7	Small pondweed
PORI2	Richardson's pondweed
POZO	Flat-stemmed pondweed
UTMA	Common bladderwort
VAAM3	Wild celery, eel grass
WO?LF	Watermeal
ZAPA	Horned pondweed
ZODU	Water stargrass
Count	34

Appendix D. Griffy Lake Public Meeting Survey Summary

Public Meeting, November 29, 2004
Showers Council Chambers

Lake Use Survey Results (11 Total Surveys Completed)

How many years have you been using the lake?

- 2 or less (5)
- 2-5 years (1)
- 5-10 years (1)
- More than 10 years (4)

How many times do you visit/use the lake in a year?

- 2 or less (5)
- 3-10 (3)
- 10-20 (1)
- >20 (2)

How do you use the lake (mark all that apply)?

- Swimming (1)
- Fishing (7)
- Boating (7)
- Other (specify): Hiking (5), Watching Waterfowl (1), Dog Use (1), Natural Beauty (1)

Does aquatic vegetation interfere with your use or enjoyment of the lake?

- Yes (7)
- No (4)

Are you in favor of efforts to control vegetation on the lake?

- Yes (11)
- No (0)

Are you aware that LARE funds will only apply to work controlling invasive exotic species, and more work may need to be privately funded?

- Yes (5)
- No (6)

Mark any of these you think are problems on your lake:

- Too many boats access the lake (0)
- Too much fishing (0)
- Fish population problem (1)
- Dredging needed (1)
- Too many aquatic plants (6)
- Not enough aquatic plants (0)
- Poor water quality (1)

Comments:
"The use of the term aquatic plants is very vague in this questionnaire – we're ONLY concerned with invasive exotics/non-native species that disrupt 'normal' ecologic processes."
"Griffy is a gem! Let's keep it vibrant."
"Sedimentation"
"Aurora Alternative High School would like to become involved in Griffy lake."